Industrial
QUALITY CONTROL

SEPTEMBER, 1953 Vol. X No. 2

AMERICAN SOCIETY FOR QUALITY CONTROL

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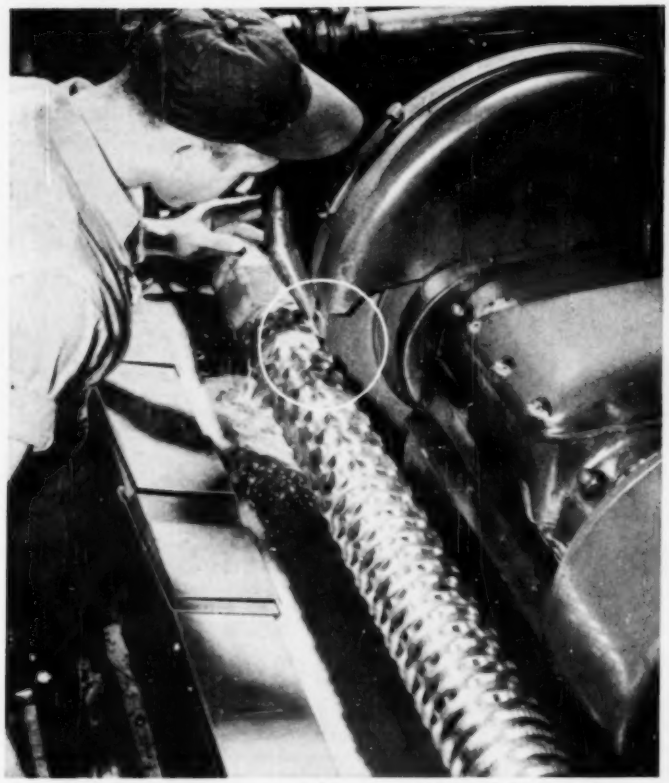

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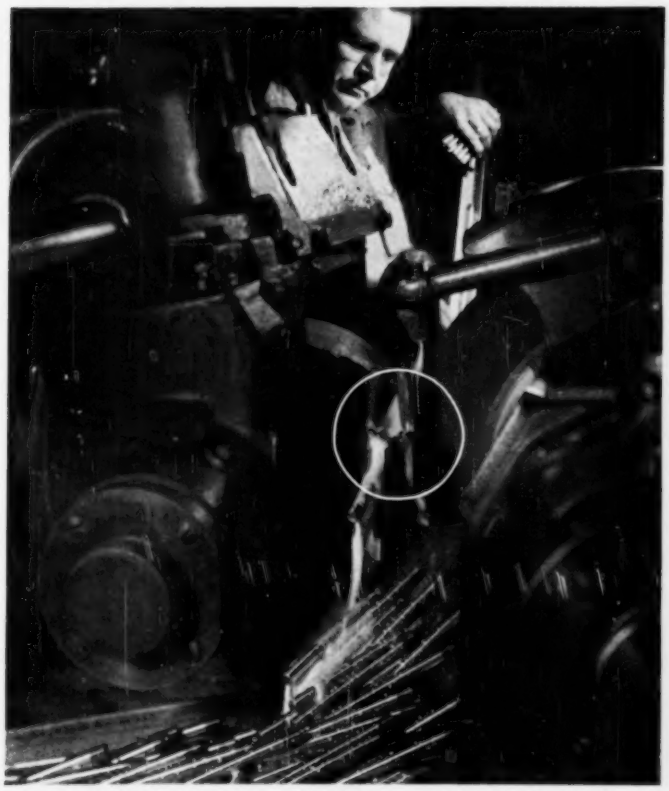

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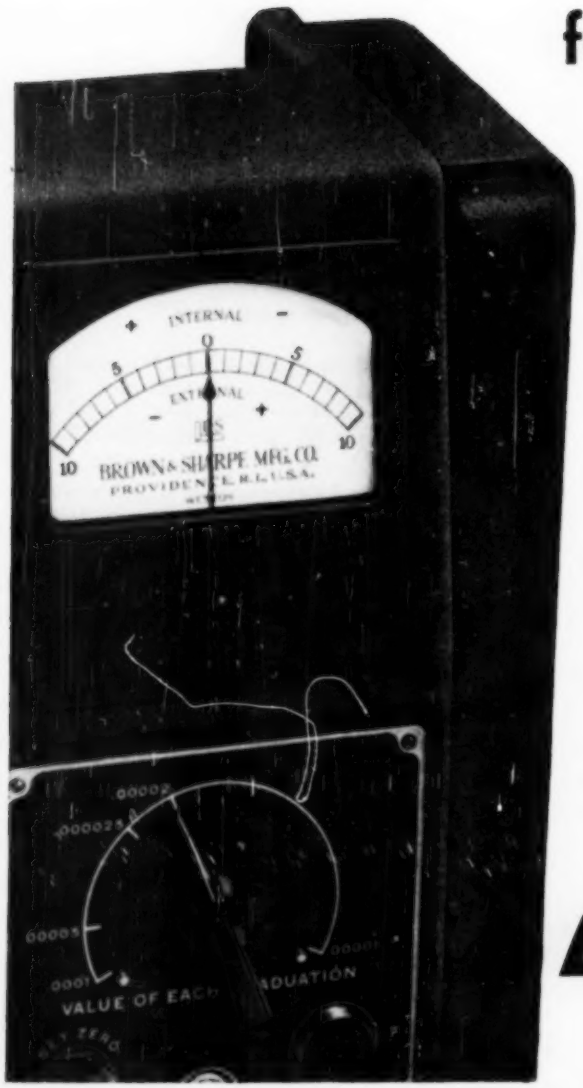

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Industrial Quality Control

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ERNEST H. ROBINSON RETIRES AS EDITOR OF NEWS SUPPLEMENT

In announcing the resignation of Ernie Robinson as editor of the News Supplement, effective July 1, 1953, it is fitting to review the background of this publication and to pay tribute to the excellent and faithful service Ernie has rendered the Society in managing this important activity.

Since the beginning of the publication of *Industrial Quality Control* in July 1944, the presentation of notes covering quality control meetings in all parts of the country has been one of the Society's most important activities in developing membership interest. However, as early as September 1946, Martin Brumbaugh, then editor of IQC, recognized that the screening and editing of these notes would always be a sizeable task. Anticipating the need for assistance in this area, arrangements were made to channel all such information through Ernie Robinson, then chairman of the Publicity Committee.

During 1946 it was becoming increasingly apparent that there was not sufficient space in IQC to do justice to both these notes and the articles. Furthermore, there were strong objections to the fact that nearly two months would elapse between the time the news was sent in by the section secretary and the time the magazine reached the readers. Therefore, when Ernie suggested that a separate publication be established to handle the local section news items and that this publication appear on months alternate with IQC, the Executive Committee immediately approved the plan. With the establishment of the News Supplement it was natural that Ernie be asked to continue with this responsibility, and he accepted the appointment as editor on a "temporary" basis, publishing the first issue of the News Supplement in June, 1947.

"Temporary" in this case turned out to span a period of six years. During this time the growth of the Society has imposed an increasingly heavy burden in the matter of gathering, consolidating and editing News Supplement material. Ernie has done a magnificent job of keeping the Supplement in step with this expansion.

The Society pays tribute to Ernest H. Robinson, who has been director of quality control at the Chicago plant of Johnson & Johnson since 1933, not only for his cooperation in undertaking and carrying forward this very important assignment during the formative years of the Society, but also for his willingness to serve on the Constitution and By-Laws, Shewhart Medal, Nominating, and as chairman of the Publicity and Public Relations committees. He has written two articles appearing in IQC, "Quality Control Department as a Training Ground for Future Supervisory Personnel" (Vol. VI, No. 4) and "Building Morale for Quality Control" (Vol. VIII, No. 6). In addition he has found time to take part in the Midwest activities as Vice President (1945-46), President (1946-47), and National Director (1947-49) for the Chicago Section.

These achievements represent an exemplary record of constructive service in which Ernie may well take pride and for which the Society herewith expresses its sincere appreciation.

SQC HELPS IN BAGGAGE HANDLING

Our cover picture comes from Dale Lobsinger, Superintendent of Management Controls, United Air Lines, Inc.

United Air Lines finds that a vital problem of service is that related to accurate and efficient handling of baggage belonging to the customer. Data show that the average passenger carries 1.2 pieces of luggage—meaning that daily volumes over this airline reach 9,600 to 12,000 pieces. Because of the multiple handling required, the exposure to error is considerable.

$\bar{X}$ and R techniques have been used to gain a better understanding of "where," "why," and "how" breakdowns occur. In the picture, agents are shown inspecting a cart of bags which is one of five selected at random for the particular station.

Immediately after instituting the control chart and data sheet procedure, it was possible to isolate several areas of weakness and then to proceed with methods for improvement. One area that responded especially well was that in which agents were tagging to wrong destinations. In this instance the data sheets served importantly as training aids.

Industrial Quality Control

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by the
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Correspondance concerning the general management and operation of IQC; inquiries regarding advertising rates, contracts, and available space; and correspondence concerning news items or other matters for the IQC NEWS SUPPLEMENT should be addressed to
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Back issues, comprising Volumes I through IX are available at $8.00 per volume, including the Index. Individual issues are $1.50 each.

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Membership in the American Society for Quality Control is available in three grades through local Sections or directly through the Executive Secretary. Annual dues for direct national membership are: for Members, $10.00; for Senior Members, $12.00; for Fellows, $16.00. In each grade, $3.00 of the annual dues are allocated as a subscription to INDUSTRIAL QUALITY CONTROL. The Member grade is open to any person of good character who is 21 years of age and engaged or interested in quality control. Information covering higher grades of membership and concerning local Sections may be obtained from the Executive Secretary.

Membership in the Society is personal and professional, and is not open to corporations, companies, or other organizations.

Contributions to the Society from corporations, companies, and others for the support of its activities are welcomed and appreciated.

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Annual Report
of the
Board of Directors
American Society for Quality Control, Inc.

The Board of Directors of the American Society for Quality Control, Inc., presents herewith its Annual Report covering the fiscal year from July 1, 1952, to June 30, 1953. This report is intended as a brief summary of the major Society activities, since detailed information was published in *Industrial Quality Control* throughout the past year.

ANNUAL MEETING

The Annual Meeting of the American Society for Quality Control, Inc., was held on Wednesday afternoon and Thursday evening, May 27 and 28, during the Seventh Annual Convention at Philadelphia, Pa.

As required by the Constitution, the President, Executive Secretary, Treasurer and Chairman of the Editorial Board, on behalf of the Board of Directors, presented their annual reports to the Society members who attended the Wednesday afternoon portion of the meeting.

At the second portion of the meeting, held on Thursday evening after the Annual Banquet, the Committee of Tellers presented its report covering the results of balloting on the proposed constitutional amendments and for the new officers. The report of the Committee of Tellers is appended hereto as Appendix D of this report.

BOARD OF DIRECTORS MEETING

The only meeting of the Board of Directors during the past year was held on Saturday afternoon, May 30, at the Benjamin Franklin Hotel, Philadelphia, Pa., immediately following the Annual Convention. On invitation of the President the incoming officers and Board members also attended this meeting.

The first item of business was an announcement by the President S. Collier, that the three proposed amendments to the Constitution had been approved by the Society membership. The President then went on to report on his personal activities. He stated that in his opinion much of the growing strength of the Society depended on the ability of the officers to put in personal appearances at the various local section meetings. He said that since May 1, 1952, he himself had been able to visit 25 sections and that the other officers had visited as many sections as they could. He went on further to say that the incoming officers were going to continue with this policy and that they were planning to schedule their visits so that a greater number of sections could be reached during the coming year.

The President reported and the Board approved the action of the Executive Committee in chartering 11 new sections and two divisions. The divisions, which are the first to be chartered by the Society, are the Textile Division which was presented its charter during a textile conference at Clemson College on Aug. 22-23, 1952, and the Chemical Division which was presented its charter during the Princeton Conference on Dec. 5-6, 1952. Both of these divisions have been working very diligently to accomplish their aims of furthering the application of SQC in their respective fields, and both participated in the Annual Convention by providing programs for their portion of the technical sessions.

The President reported the major items from the reports of the chairmen of the 33 Society committees, of which the report of the Examining Committee is included as Appendix E. The President also presented the report of the Auditing Committee in which several recommendations concerning our financial program were made to the Board of Directors. Action on this report was deferred until the first Executive Committee meeting on Sept. 20.

The Executive Secretary, Edward Haden, the Treasurer, Paul Robert, and the Chairman of the Editorial Board, Mason Wescott, each presented his annual report. These reports have been extended to include the end of the fiscal year and are presented herewith as Appendixes A, B, and F, respectively.

The report of the Committee on Constitution and By-Laws was presented by its chairman, George Edwards.

Wade Weaver, Chairman of the Financial Advisory Committee, presented this committee's report, which is included herewith as Appendix C. The President announced that the Executive Committee had approved the three principal recommendations in this report; namely, (1) that the profits accrued as a result of transfers in the investment portfolio be used for reinvestment purposes, (2) that the principal amount of the profits of the Philadelphia Convention be transferred to the investment account for the purchase of U. S. Treasury Bonds, and (3) that the ultimate aim of our investment portfolio should be to provide the Society with a sinking fund approximately equal to three times the annual budget. Discussion on the last point brought out the opinion that while sound fiscal policy certainly dictated as large a sinking fund as possible, the achievement of the goal recommended by the committee would be extremely difficult. This difficulty notwithstanding, it was agreed that this goal was a worthwhile objective.

At the request of its chairman, Wade Weaver, the report of the Section Representation Committee was postponed to the Sept. 20 Executive Committee meeting.

Paul Robert, Chairman of the newly established Section Management Award Committee, outlined to the Board the purpose of the award and briefly described the various section activities on which the award would be based. He also announced the appointment of Robert Hofstead as Vice Chairman. It is planned that the other members of this committee will be the chairmen of the following committees: Membership, Program and Speakers, Editorial Board, Publicity, and Education and Training.

At the close of the meeting the incoming President, Alfred Davis, announced that the new Executive Committee had decided not to reprint the Constitution and By-Laws at this time. He said that while the approved amendments made the present copies obsolete, the Executive Committee decided to delay the reprinting until action is taken on some other changes which will be proposed this year.

Mr. Davis asked that each Board member, as the retiring National Director for his section, turn over his copy of the

Operating Handbook to the new section chairman for next year. He further asked that each member assume the responsibility to see that each section secretary turn over his book to next year's secretary.

EXECUTIVE COMMITTEE MEETINGS

Five meetings of the Executive Committee were held during the year, as follows:

New York—September 13-14, 1952
Indianapolis—November 21-22, 1952
New York—February 6-7, 1953
New York—April 24-25, 1953
Philadelphia—May 26, 1953

These meetings were devoted to problems involved in the operation of the Society and to plans relating to future expansion. The major actions of the committee were published in *Industrial Quality Control* during the year.

MEMBERSHIP

The applications of 11 more sections were accepted during the year. Thus, the number of sections increased from 60 to 71, and the total membership from 6109 to 7430. The complete story of the Society's membership picture is contained in the Executive Secretary's report (Appendix A).

MEETINGS

It may be safely stated that the past growth of our Society, and indeed its continued healthy growth, can be attributed largely to the caliber and frequency of local section meetings. The reason for this is that in many cases the section meeting is the principal contact between our Society and our newer members. Consequently, since the techniques of applying SQC are so varied and many times difficult, our newer members have received a great deal of benefit from the fact that our sections devote a large portion of their meetings to papers which are presented by our more experienced members.

In addition to section meetings, the regional conferences have also played an important role in our Society growth since they provide a means whereby larger groups of members can come together and benefit from the intimate contacts that are made. Recognizing the great importance of these conferences and also realizing that their value would be seriously impaired if they conflicted too much with each other or with the Annual Convention, the Executive Committee approved the establishment of the Regional Conferences Committee.

The purpose of this committee is:

1. To implement the National policy in conducting regional conferences and clinics.
2. To coordinate the activities of the various regional conferences and clinics by compiling and clearing all scheduled dates at least one year in advance so as to minimize conflicts with national meetings and other ASQC activities.
3. To make this schedule of meeting dates available to other technical societies in order to prevent overlapping of schedules and to promote joint conferences.
4. To aid in the establishment of new conferences in areas not presently served.
5. To aid in the establishment of clinics for specialized applications by divisions and technical committees.
6. To provide an agency for reporting these activities to the national Society and for evaluating and exchanging information among the regions and divisions.

The third and equally important Society activity which has contributed so much to our growth is, of course, the Annual Convention. Only by participation in the convention can our members develop an appreciation of the stature and broad national scope which the field of SQC has achieved. It is most gratifying to report that the Philadelphia Convention was the most successful one held to date, with a record number of 2567 persons attending the technical, educational and exhibit sessions and with an additional 772 persons viewing the 44 industrial exhibits. This successful convention was made possible because of the excellent planning and execution by the general and local convention committees.
The complete report of the Seventh Annual Convention was presented in the July 1953 issue of IQC.

PUBLICATIONS

Although the complete details of the publications activities are contained in the Editorial Chairman's report (Appendix F), the highlights of these activities are presented here. As in the past, the Editorial Board this year has continued its splendid work in carrying out the program of making our publications more valuable to our members. A part of this program was the establishment of the Publications Office at Milwaukee under the direction of your Managing Editor. During the past year the following functions have been consolidated in this office as planned: (1) final processing, publishing and distributing of *Industrial Quality Control*, (2) editing and processing of the News Supplement, and (3) soliciting and servicing IQC advertisers.

During the year the Editorial Board has established, and the Executive Committee has approved, two new classes of publications—Standards Committee Reports and General Publications Series. The first Standards Committee Report to be published was No. A1-1951, "Definitions and Symbols for Control Charts." The first of the General Publications Series to be published was "Manual on Sampling Inspection by Military Standard, MIL-STD-105A." Also under preparation by the Program and Speakers Committee is a booklet entitled "Suggestions to Authors of Technical Papers" which is designed to assist authors in the preparation and publication of their papers.

The Executive Committee also approved the establishment of Division publications. The first to appear in this category was the Textile Division Technical Supplement which was published in August 1952.

AWARDS

At the Thursday evening portion of the Annual Meeting of the Society in Philadephia the following awards were presented:

The 1952 Shewhart Medal to Professor Eugene L. Grant of Stanford University, Stanford, California, because of his outstanding contributions to the science of quality control, successful promotion of management of quality control programs, and service to the art and to the Society. The citation was presented by Major General Leslie E. Simon, United States Army. The medalist address and the citation were published in the July 1953 issue of *Industrial Quality Control*.

The 1952 Brumbaugh Award to Messrs. Albert G. Klock and Charles W. Carter, co-authors of the article "Woolen Carding Meets Quality Control" which was published in the May 1952 issue of IQC.

ACKNOWLEDGMENT

The Board of Directors wishes to express its sincere appreciation to the Executive Committee, all Society committees, and committee chairmen, and to all section officers, for the splendid work done during the year. The loyal support and contributions of personal time and effort have been responsible for the development and strengthening of our Society, and the Board acknowledges these contributions with genuine thanks.

New York, N. Y.
June 30, 1953

For the Board of Directors
S. COLLIER, President

Appendix A: Report of the Executive Secretary

The membership picture at the close of the 1952-53 fiscal year had its encouraging and disappointing aspects. Among the former is the fact that our membership as of June 30, 1953 was 7430, which is the largest in our history and marks the first time we have exceeded seven thousand members. It is also encouraging to note that during the year 1952-53 we have received 2846 new members, which is more than we have ever received in any previous year of the society's history as shown in Exhibit A.

The membership of the Society as of June 30, 1953 was composed as follows:

	New Members	Renewing	Total
Fellows	0	146	146
Senior Members	343	1589	1932
Members	2484	2837	5321
Members in Training	19	12	31
	2846	4584	7430

By comparing the above totals with those of June 30, 1952 we come to the disappointing factors of the membership picture. The percentage of renewals from previous fiscal years, after climbing from 75 percent to 81 percent between June 30, 1949 and June 30, 1952, has dropped to 75 percent again. Our net gain for this past year was 1321, a drop of 543 as compared to the year 1951-52.

It should be noted that during the fiscal year 1952-53, 86 percent of the 1951-52 Senior members and Fellows renewed their memberships, as compared with 70 percent of the Member Grade members renewing. The comparable figures last year were 92 percent and 75 percent. This gives us significant evidence of the need for greater effort on the part of the various sections to do more work in keeping their members active.

During the 1952-53 fiscal year there were 205 transfers from one Section to another. Some of the large numbers of transfers in one group were 32 from the Boston Section to the new Worcester Section and 15 from the Greater Muskegon to the new Grand Rapids Section. The membership status of the various sections is shown in Exhibit B.

New Sections recognized during this year in order of their recognition are as follows:

Louisville	61
Trenton	62
Richmond	63
Lincoln	64
Kansas City	65
Japan	66
Salt Lake City	67
Grand Rapids	68
New Haven	69
Youngstown	70
Carolinas	71

In accordance with the provisions of the Society constitution, since January 1, 1953, we have been accepting new memberships in the Society in the Member grade only. Members qualified for the Senior grade may transfer to that grade at a later date with the concurrence of their respective Sections and the Examining Committee.

In sending out bills for renewal dues for the 1953-54 year we are for the first time including each member's membership card for the new fiscal year. This is to eliminate the delay between the time the member pays his dues and receives his card and will also serve to reduce our work-load. To reduce the interval between the time a new member joins the Society and receives his membership card, the Sections will continue to have a supply of these cards to issue to new members rather than having cards for all new members sent out from the National Office as was done prior to the middle of the 1952-53 year.

We published the Society Yearbook this year, a copy of which was sent to each member in good standing who requested one. We are sending one to each new member of the Society as he joins until our supply is exhausted.

Membership Certificates are available for $3.00 to members in good standing who order them.

In accordance with the directions of the Executive Committee each new Section as it is admitted to the Society will receive a Section Charter. All present Sections will also receive Charters.

The office of the Executive Secretary continues to act as an employment clearing house between members of the Society and industry. This operation is not always as successful as it might be, since the majority of those asking us to help them obtain positions are relatively inexperienced in the field and most of the positions available of which we have been notified are in the middle or upper ranks of quality control personnel.

As of December 1952 the staff of the Executive Secretary's office was expanded from two to three people, and during June 1953 a new and larger office was obtained to house this staff and its necessary equipment. These moves have been made to enable your Executive Secretary to execute better his obligations to the members of our Society.

In retiring from office in this Society, I extend my sincerest thanks to the officers and members who have given me such valued assistance over the years. I am particularly grateful to Mr. Julian Herz who has served so well an Manager of our Society headquarters office in New York.

Respectfully submitted,

EDWARD B. HADEN
Executive Secretary

New York, N.Y.
July 10, 1953

Exhibit A—Record of Membership Growth

Date	Members	% Renewal	Net Gain	% Gain	New Members	Active Sections	Members Rec'd for following Fiscal Year
June 30 '47	1926				1926	25	*
June 30 '48	2102	*	176	9	*	31	*
June 30 '49	2638	75	536	25	1058	35	*
June 30 '50	3510	77	872	33	1489	42	58
June 30 '51	4245	80	735	21	1422	48‡	167
June 30 '52	6109	81	1864	44	2669	60	207
June 30 '53	7430	75	1321	22	2846	71	146

*No record. ‡One provisionally accepted.

Exhibit B—Membership Report as of June 30, 1953

New England Region	Membership June 30, 1952 Total	Membership June 30, 1953 Fellows	Sr. Members	Members	Total
Albany	53	1	16	64	81
Buzzards Bay	39		2	50	52
Boston	177	2	40	103	145
Hartford	184	2	36	153	191
N. Hampshire	24	1	5	14	20

Exhibit B—Membership Report as of June 30, 1953 (Concl.)

	Membership June 30, 1952	Membership June 30, 1953			
New England Region (Cont.)	Total	Fellows	Sr. Members	Members	Total
Rhode Island	35	1	12	36	49
So. Conn.	95	1	37	91	129
W. Massachusetts	61	3	26	56	85
Worchester	...	1	7	41	49
Total	668	12	181	608	801
Middle Atlantic Region					
Allentown-Bethlehem	...	1	9	62	72
Baltimore	62	2	18	71	91
Delaware	40	4	10	37	51
Lansdale	104	1	11	81	93
Metropolitan	430	28	183	347	558
Philadelphia	217	6	85	202	293
Richmond	...	..	10	43	53
Trenton	...	..	11	50	61
Washington	74	3	21	51	75
Total	927	45	358	944	1347
Northern Region					
Buffalo	68	1	19	63	83
Mid-Hudson	45	.	14	50	64
Montreal	62	1	14	74	89
Rochester	103	6	67	29	102
So. Tier	86	1	20	76	97
Syracuse	132	2	23	124	149
Toronto	82	1	9	74	84
Utica	...	.	14	42	56
W. Ontario	55	.	18	34	52
Total	633	12	198	566	776
Central Region					
Birmingham	47	.	3	42	45
Cincinnati	66	1	14	67	82
Cleveland	299	7	101	224	332
Columbus	45	1	18	42	61
Dayton	107	3	19	114	136
Erie	51	.	3	32	35
Georgia	46	2	22	48	72
Gr. Rapids	...	.	2	43	45
Greater Muskegon	40	.	9	14	23
Huntsville	49	.	4	6	10
Louisville	...	.	11	52	63
Michigan	278	6	64	230	300
Parkersburg	34	.	2	36	38
Pittsburgh	78	4	27	53	84
Tennessee	61	1	19	52	72
Toledo	80	1	11	89	101
Total	1281	26	329	1144	1499
Midwest Region					
Central Illinois	35	2	20	13	35
Chicago	402	10	125	364	499
Dallas-Ft. Worth	197	..	56	74	130
Denver	34	1	5	39	45
Evansville-Owensboro	26	..	5	25	30
Indianapolis	408	5	59	226	290
Iowa	166	8	106	107	221
Kansas City	...	..	10	33	43
Lincoln	...	1	10	29	40
Milwaukee	276	2	69	175	246
Minnesota	60	2	22	59	83
Muncie	36	..	12	78	90
N. E. Indiana	55	2	13	51	66
Racine	50	1	18	34	53
Rock River Valley	45	2	12	32	46
St. Louis	141	6	31	84	121
So. Texas	61	1	5	49	55
Wichita	38	..	32	96	128
Total	2030	43	610	1568	2221
Western Region					
Japan	...	.	13	38	51
Los Angeles	112	4	60	109	173
Mexico City	22	.	1	25	26
Salt Lake City	...	..	...	27	27
San Francisco	56	1	23	52	76
San Diego	133	.	112	44	156
Seattle	33	.	3	56	59
Total	356	5	212	351	568
Members-at-Large	165	3	44	140	187
Members-in-Training	49	..	..	...	31
GRAND TOTALS	6109	146	1932	5321	7430

Appendix B: Report of the Treasurer

Herewith are the Balance Sheet of the Society as of June 30, 1953, (Exhibit C), the Statement of Cash Receipts and Disbursements for the fiscal year ended June 30, 1953 (Exhibit D), and the Record of the Marketable Securities held by the Society as of June 30, 1953 (Exhibit E).

Endicott, N. Y.
June 30, 1953

PAUL A. ROBERT
Treasurer

Exhibit C—Balance Sheet as of June 30, 1953

ASSETS

Cash:				
Current funds:				
Demand deposit		$ 9,055.78		
On hand for deposit		518.70		
Time deposits—general		21,125.85		
Time deposit—Convention reserve fund		6,266.84	$36,967.17	
Petty cash funds			251.25	
Special funds:				
Demand deposits:				
Textile Division Fund	$ 30.90			
Chemical Division Fund	60.98			
Investment Income Fund	379.25	$ 471.13		
Time deposits:				
Shewhart Medal Fund	$ 755.19			
Brumbaugh Award Fund	1,815.20	2,570.39	3,041.52	$40,259.94
Marketable securities (at cost):				
United States Treasury Bonds (market value $7,674.00)			$ 7,884.06	
Other marketable securities (market value $36,710.00)			37,545.59	45,429.65
Accounts receivable:				
From sales of advertising, magazine reprints, conference papers, technical literature, etc.			$ 1,422.33	
Advances to 1954 and 1955 Convention Committees			1,100.00	2,522.33
Inventories—at nominal amounts:				
Back issues of Industrial Quality Control, conference papers and other technical literature			$ 1.00	
Stationery and supplies			1.00	2.00
Office furniture and equipment at nominal amount				1.06
				$88,214.92

LIABILITIES AND SURPLUS

Accounts payable			$ 308.85
Pay roll taxes and taxes withheld from employees			820.12
Deferred income:			
Membership dues paid in advance		$ 917.00	
Estimated unearned portion of library subscriptions		1,466.00	2,383.00
Reserves:			
For Shewhart Medal Fund		$ 755.19	
For Brumbaugh Fund		$ 1,815.20	2,570.39
Surplus			82,132.56
			$88,214.92

Exhibit D—Statement of Cash Receipts and Disbursements, Year Ended June 30, 1953

CURRENT FUNDS

Receipts			
Membership dues:			
Members in training		$ 109.50	
Regular members		29,417.50	
Senior members		15,250.00	
Fellows		1,720.00	
Overpayments, less refunds		75.75	$46,572.75
Publications:			
Advertising	$21,362.90		
Library subscriptions	3,331.90		
Sales of back issues	2,002.31		
Sales of reprints	436.59	$27,133.70	
Less cost of reprints		321.30	26,812.40
Sales of pins and insignia		989.73	
Less cost of pins and insignia		374.17	615.56
Interest received on bank deposits			947.66
Annual Society Conventions:			
For year ended June 30, 1953	$14,131.17		
For year ended June 30, 1952	68.21	$14,199.38	
Less expenses for year ended June 30, 1952 paid after closing		243.22	
		$13,956.16	
Refund by 1953 Committee		1,000.00	14,956.16
Income and social security taxes withheld from employees	$ 2,557.21		
Less payments to Collector of Internal Revenue	2,383.95	$ 173.26	
Refund of social security taxes paid		278.61	451.87
Miscellaneous income			27.74
TOTAL			$90,384.14

Exhibit D—Statement of Cash Receipts and Disbursements, Year Ended June 30, 1953 (Cont.)

CURRENT FUNDS (Concl.)

Disbursements			
Publications:			
Cost of authors' reprints	$ 859.72		
Less cash received from authors	351.38	$ 508.34	
Cost of printing conference papers and other technical literature	$ 1,732.75		
Less cash received from sales	1,093.62	639.13	
Publishing—magazine		18,198.54	
Publishing—news supplement		1,415.00	
Publishing—index		265.75	
Postage and mailing expense:			
Magazine		2,317.84	
News supplement		743.98	
Back issues		483.35	
General		258.42	
Office supplies and expense		663.33	
Secretarial services		2,383.64	
Managerial services		5,500.00	
Office salaries		1,397.00	
Advertising commissions and cash discounts allowed		2,198.28	
Office furniture and equipment purchased		1,392.63	
Rent		808.50	
Traveling expenses		794.59	
Printing and mimeographing		30.00	
Sundry		.02	$39,998.34
Committees and Sections:			
Public relations material, postage, and sundry expense		$ 114.52	
Executive Committee meetings and sundry expenses		705.80	$ 820.32
President and Vice President:			
Office supplies and sundry expense		$ 246.48	
Traveling expense		236.90	483.38
Executive Secretary:			
Secretarial salaries		$ 9,889.20	
Publishing yearbook		3,204.94	
Postage and mailing expense—yearbook		354.43	
Printing and mimeographing		2,706.71	
Postage		1,099.70	
Office supplies and expense		1,188.00	
Less reimbursement by sections		595.51	
Office rent		688.19	20,857.81
Traveling expense			
Office furniture and equipment purchased	$ 1,282.50		
	151.37	1,131.13	
Treasurer:			
Office supplies and expense		$ 85.44	
Insurance		746.65	
Traveling expense		187.80	
Accounting services		309.57	
Postage		.55	1,330.01
Divisions:			
Publishing technical supplement, etc.		$ 2,539.98	
Postage and mailing expense—technical supplement		539.05	3,079.03
General:			
Pay roll tax expense		$ 183.84	
Transfer to Investment Income Fund		25,027.61	
Advances to 1954 and 1955 Convention Committees		1,500.00	
Increase in amounts of imprest petty cash funds		126.25	
Cost of printing membership certificates	$ 600.60		
Less cash from sales	72.00	528.60	
Costs of Society films, less rentals received		66.13	27,432.43
TOTAL			$94,001.32
CASH DISBURSEMENTS IN EXCESS OF CASH RECEIPTS			$ 3,617.18
Cash on hand and on deposit at June 30, 1952			40,584.35
Cash on hand and on deposit at June 30, 1953			$36,967.17

SPECIAL FUNDS

Textile Division Fund			
Receipts:			
Membership dues		$ 339.16	
Sales of technical literature		4.00	
Less cost of literature	$ 42.92		
	42.92	-0-	$ 343.16
Disbursements:			
Contribution by Textile Technical Committee			
Printing and mimeographing		$ 160.28	
Postage		29.00	
Sundry		122.98	312.26
Cash on deposit at June 30, 1953			$ 30.90

Exhibit D—Statement of Cash Receipts and Disbursemen ts, Year Ended June 30, 1953 (Concl.)

SPECIAL FUNDS (Concl.)

Chemical Division Fund

Receipts:		
Membership dues		$ 193.00
Disbursements:		
Office supplies and expense		132.02
Cash on deposit at June 30, 1953		$ 60.98

Shewhart Medal Fund

Receipts:		
Contributions by various sections	$ 446.00	
Interest received on bank deposit	10.06	$ 456.06
Disbursements:		
Cost of engraving medal and preparation of certificate		52.11
CASH RECEIPTS IN EXCESS OF CASH DISBURSMENTS		$ 403.95
Cash on deposit at June 30, 1952		351.24
Cash on deposit at June 30, 1953		$ 755.19

Brumbaugh Award Fund

Receipts:		
Contributions by various sections	$ 792.50	
Interest received on bank deposit	27.95	$ 820.45
Disbursements:		
Cash award to Albert G. Klock	$ 50.00	
Cash award to Charles W. Carter	50.00	100.00
CASH RECEIPTS IN EXCESS OF CASH DISBURSMENTS		$ 720.45
Cash on deposit at June 30, 1952		1,094.75
Cash on deposit at June 30, 1953		$ 1,815.20

Exhibit E—Marketable Securities as of June 30, 1953

Description	Rate and Maturity	Principal Amount	Cost	Market Value	Income Received
UNITED STATES BONDS					
U. S. Treasury bonds	2 3/8's 1959	$5,000.00	$ 4,973.75	$ 4,860.00	$ -0-
U. S. Treasury bonds	2 1/2's 1969	3,000.00	2,910.31	2,814.00	75.00
			$ 7,884.06	$ 7,674.00	$ 75.00
OTHER BONDS					
Aluminum Co. of America	3 1/8's 2/ 1/64	2,000.00	1,997.85	1,997.50	-0-
American Telephone and Telegraph Co.	2 3/4's 12/15/61	1,000.00	1,075.80	1,093.75	27.50
American Tobacco Co.	3 's 4/15/62	2,000.00	1,963.50	1,975.00	-0-
Bethlehem Steel Corp.	2 3/4's 7/15/70	1,000.00	915.80	930.00	-0-
Cincinnati Gas & Electric Co.	2 3/4's 10/ 1/75	2,000.00	1,839.10	1,855.00	-0-
Cleveland Electric Illuminating Co.	3 's 7/ 1/70	1,000.00	1,013.30	972.50	15.00
Consolidated Edison Co. of New York	3 's 11/ 1/72	1,000.00	963.30	965.00	-0-
Dow Chemical Co.	3 's 7/ 1/82	2,000.00	2,100.40	1,977.50	-0-
Firestone Tire & Rubber Co.	3 's 5/ 1/61	2,000.00	2,012.90	1,980.00	30.00
Pacific Gas & Electric Co.	3 1/2's 6/ 1/66	2,000.00	2,057.85	2,020.00	17.50
Pennsylvania R. R. Co.	4 1/4's 4/ 1/81	2,000.00	1,958.50	1,880.00	-0-
Standard Oil Co. of New Jersey	2 3/4's 7/15/74	2,000.00	1,811.00	1,840.00	-0-
Union Oil Co. of California	3 1/8's 5/ 1/72	2,000.00	2,150.40	2,005.00	31.24
			$21,859.70	$21,491.25	$ 121.24
PREFERRED STOCKS	Shares		Par		
Consolidated Edison Co. of New York	10	$5 Cum.	N.P.	1,094.10	1,065.00	50.00
E. I. duPont de Nemours and Co.	15	3.5 % Cv.	N.P.	1,392.15	1,650.00	-0-
Public Service Electric & Gas Co.	50	$1.40 Div.	$ 35.00	1,387.56	1,256.25	-0-
Southern California Edison Co.	40	4.48% Cv.	25.00	1,154.91	1,175.00	-0-
Sylvania Electric Products	10	4.40% Cv.	N.P.	1,071.60	990.00	-0-
Virginia Railway Co.	40	6 % Cum.	25.00	1,159.76	1,090.00	60.00
				$ 7,260.08	$ 7,226.25	$ 110.00
COMMON STOCKS						
American Telephone & Telegraph Co.	10		100.00	1,570.35	1,535.00	-0-
Cleveland Electric Illuminating Co.	20		N.P.	1,051.20	995.00	13.00
Commonwealth Edison Co.	30		25.00	1,075.51	1,027.50	-0-
General Public Utilities Corp.	40		5.00	1,019.30	980.00	32.00
National City Bank of New York	25		N.P.	1,343.75	1,225.00	12.50
Norfolk of Western R. R.	25		25.00	1,207.32	1,131.25	-0-
Pacific Gas & Electric Co.	30		25.00	1,158.38	1,098.75	-0-
				$ 8,425.81	$ 7,992.50	$ 57.50
				$45,429.65	$44,384.00	$ 363.74

Add:		
Cash on deposit—June 30, 1952	$ 246.78	
Proceeds from sales of securities	18,647.92	
Dividends and interest received on securities sold	680.66	
Transfer from current funds	25,027.61	44,602.97
		$44,966.71
Deduct:		
Purchase of securities	$44,406.04	
Interest purchased	180.84	
Bank service charges	.58	44,587.46
CASH ON DEPOSIT—CLEVELAND TRUST COMPANY		$ 379.25

Certificate of Audit

We have examined the balance sheet of American Society for Quality Control, Incorporated as of June 30, 1953 and the statement of cash receipts and disbursements for the year then ended and, without making a detailed audit of the transactions, have examined or tested accounting records maintained by the Treasurer of the Society, and other supporting evidence as hereinafter outlined.

Petty cash funds were reported to us by the custodians of the funds and cash on hand for deposit was counted by us. Cash on deposit at June 30, 1953 was reconciled with amounts confirmed to us by the depositaries. We traced the recorded cash receipts for a period of four months selected by us to deposits shown by bank statements on file, and examined cancelled bank checks, invoices, and other data supporting the recorded disbursements for the same period. We satisfactorily accounted for the recorded cash received for membership dues for the year ended June 30, 1953 by inspection of the underlying records. We also reconciled recorded amounts for sales of advertising and reprints for the year ended June 30, 1953 with amounts reported to us by the Managing Editor of the Society publication.

Marketable securities, held in custody of the Deputy Treasurer, were inspected by us, and we reconciled the reported income therefrom with the cash on deposit which was reported to us by Cleveland Trust Company.

Accounts receivable at June 30, 1953 are included as shown by unpaid invoices on file as of that date, and deferred income is based upon the underlying records.

In our opinion, based upon our examination as outlined above, the accompanying balance sheet and statement of cash receipts and disbursements present fairly the financial position of American Society for Quality Control, Incorporated at June 30, 1953 and the recorded cash transactions of the Society for the year then ended.

ERNST & ERNST

Rochester, N. Y.
July 8, 1953

Appendix C: Report of the Financial Advisory Committee

Society funds invested in securities as of June 30, 1953 total $45,429.65. Details of this portfolio, together with the approximate market value of the securities on June 30, 1953, are published as Exhibit E of the Treasurer's report. The investments produced a yield of 4.358 percent for the fiscal year just ended. The total amount shown above was not under investment for the entire fiscal year due to purchase dates.

The recent switch from our initial position of 25 percent bonds and 58 percent common stocks to the June 30, 1953 position of 65 percent bonds and 19 percent common stocks was very favorably accomplished. A net profit was realized on the common stocks sold. While these issues were held they produced a return of 5.420 percent. In addition, the bonds which replaced the common stocks were purchased at an average price of about $7.00 less than the price we would have had to pay if we had bought bonds at the time we bought stocks. This increases the yield on our investment. Further, since the bonds just purchased were acquired under par value, if they are held to maturity an additional profit of about $4.40 per $100 invested, will be realized.

Of the total amount invested, $801.23 stands as a "re-investment" of a portion of the earnings on securities held. Such practice will be continued.

The Executive Committee has authorized the transfer of the principal amount of the proceeds of the Philadelphia Convention to the Investment Account for the purchase of U. S. Treasury Bonds. After this addition to our portfolio the total Society funds invested in securities will approximate $60,000 and the securities held will be, roughly, in the following distribution:

Treasury Bonds	37%
Corporate Bonds	37%
Preferred Stocks	12%
Common Stocks	14%

The anticipated annual yield is 3.44 percent.

The Financial Advisory Committee's present objectives include a sinking fund approximately three times the magnitude of the annual Society budget.

Respectfully submitted,
IRVING W. BURR
GEORGE D. EDWARDS
WADE R. WEAVER, Chairman

Appendix D: Report of the Committee of Tellers

In accordance with Section 68b of the Constitution of the American Society for Quality Control, "Adoption of any amendment shall require a total qualified and valid vote (for and against it) of at least one-fourth of the corporate members of the Society in good standing, and at least three-fourths of that total vote shall be in favor of adoption. In addition, such adoption shall require that, with respect to each of at least three-fourths of the Sections, a majority of the ballots cast by affiliated corporate members shall be in favor of the amendment."

1. The number of corporate members of the Society eligible to vote as reported by the Executive Secretary is 7006. This does not include members-in-training who have no vote. In order to adopt any proposed amendment it requires a qualified valid vote (for and against it) of at least 1752.

2. Of the total qualified votes cast, at least three-fourths must be in favor of adoption.

3. The votes for each section must be counted separately and if the majority of the vote of a section is in favor of the amendment, it is counted as a favorable section. For adoption at least three-fourths of the sections must be favorable. The number of sections, including members-at-large as a group, is 67. For adoption at least 51 sections must vote favorably for the amendment.

The results of the vote for the three amendments are as follows:

1. *Increasing Minimum Membership Requirements for Sections*

	Number	*Percent*
Total qualified votes cast	1876	
Invalid Ballots (Not Marked)	86	
Total Ballots Cast	1962	
FOR Adoption	1626	86.7
AGAINST Adoption	250	13.3
Favorable Sections	64	
Unfavorable Sections	3	
Result: Amendment Adopted		

2. *Reorganizing Society Operations*

Total qualified votes cast	1849	
Invalid Ballots (Not Marked)	113	
Total Ballots Cast	1962	
FOR Adoption	1759	95.1
AGAINST Adoption	90	4.9
Favorable Sections	67	
Unfavorable Sections	0	
Result: Amendment Adopted		

3. *Eliminating Reference to Articles of Incorporation*

	Number	*Percent*
Total qualified votes cast	1826	
Invalid Ballots (Not Marked)	136	
Total Ballots Cast	1962	
FOR Adoption	1691	92.6
AGAINST Adoption	135	7.4
Favorable Sections	67	
Unfavorable Sections	0	

Result: Amendment Adopted

The Committee of Tellers has counted all eligible ballots that have been submitted. A total of 1962 ballots were returned of which the following were not marked and thus were invalid.

President	24
Vice President	361
Secretary	30
Treasurer	26

The results of the vote for the Election of Officers are as follows:

1. For President:

Alfred Davis	1896
Write in votes for 19 different canditates	42

Having received more votes than any other eligible member, Mr. Alfred Davis is elected as President.

2. For Vice President:

P. A. Robert	1798
R. S. Saddoris	1868
J. H. Toulouse	1800
Write in votes for 44 different candidates	59

Having received more votes than any other eligible members, Messrs. Robert, Saddoris and Toulouse are elected as Vice Presidents.

3. For Executive Secretary:

Dorian Shainin	1907
Write in votes for 19 different candidates	25

Having received more votes than any other eligible member, Mr. Dorian Shainin is elected Executive Secretary.

4. For Treasurer:

Leon Bass	1919
Write in votes for 16 different candidates	17

Having received more votes than any other eligible member, Mr. Leon Bass is elected Treasurer.

Respectfully Submitted,

CLARENCE BURDICK
LEONARD SEDER
PHILLIP PROCTOR
ERNEST ROBINSON
AUGUST MUNDEL, Chairman

May 28, 1953

Appendix E: Report of Examining Committee

Summarizing the Fellow status as of June 30, 1953, we find:

Number elected from Founding of Society to June 30, 1952			147
Losses to June 30, 1953			
Resignations	3		
Death	1		
Delinquent for dues	4	8	
Gain—June 30, 1952 to June 30, 1953			
Election by invitation	16		
Election by personal application	2	18	
Net Gain—June 30, 1952 to June 30, 1953			10
Number of Fellows on June 30, 1953			157

The action file of the Examining Committee shows the following:

Open personal applications	9
Open invitations to file applications	14
Total	23

Of the 71 sections of the Society, 44 have at least one Fellow. Of these, ten sections have at least five Fellows. Of the remaining, four have four each, three have three, 11 have two, 16 have one, and four Fellows are members at large. Thus, 27 sections have no Fellows.

Breakdown by age of section may be of interest. Indicating the age of the section by its name appearing in the Yearbook, we have:

Date	Sections	Fellows	Sections with no Fellows	Members (1953 Yearbook)
1947	24	123	0	3844
1948	6	15	1	424
1949	3	3	1	149
1951	11	10	3	431
1953	21	6	16	1197
Total	65	157	21	6045

This breakdown seems consistent with sound growth.

LLOYD A. KNOWLER
EDWIN G. OLDS
WYATT H. LEWIS
ROBERT S. INGLIS
PAUL S. OLMSTEAD, Chairman

Appendix F: Report of the Editorial Chairman

The following report summarizes what are believed to be the important features in the experience of the office of editorial chairman with respect to publication activities of the Society during the fiscal year 1952-53.

Professor Irving W. Burr, Acting Editorial Chairman

During the period September 1, 1952—February 15, 1953, the office of the editorial chairman was located at Purdue University where Professor Burr served the Society as Acting Editorial Chairman while the regular chairman was on leave of absence to India. The November, January, and March issues of Industrial Quality Control were directed by Professor Burr, who also carried forward the supervision of submitted manuscripts and maintained the normal flow of correspondence dealing with editorial management of Society publications.

The Society as a whole, and your editorial chairman in particular, are deeply indebted to Professor Burr for his willingness to accept this assignment and for the faithful and able manner in which he discharged this service.

Editorial Chairman's Office Now at Rutgers University

As noted in the September 1952 issue of IQC, the editorial chairman's office moved to Rutgers University officially as of July 1, 1952. Actual transfer took place about September 1, and activation of the office in its new location began in early February 1953 when the files were returned from Purdue.

Data on Volume IX, IQC

In Volume IX, we ran five issues at 52 pages and one at 148 pages for a total of 408 pages. This is only a 2½ percent increase over the number of pages published in Volume VIII. In addition, a 6-page Index of Volume VIII was published and inserted with each copy of the July 1952 issue of Volume IX sent out to our regular mailing list.

Of the 408 pages published in Volume IX, 163.5 were used for paid ads (including Classified Ads). This is about 40 percent of the total available space. The corresponding figure for Volume VIII was 38.3 percent. Excluding the May issue, paid advertising used 35 percent of the available space in the other five issues of Volume IX. The corresponding figure for Volume VIII was 31 percent.

About 245 pages of Volume IX were available for non-advertising copy. The approximate distribution of these 245 pages follows.

138.4 pages were used to publish 39 papers averaging about 3.5 pages per paper and ranging in length from exactly one page to a little over 7 pages. This is 7.4 pages and 4 papers more than in Volume VIII.

39.8 pages were required for departmental copy, the breakdown here being as follows:

Bibliography: 12 pages total; in each of the 6 issues.

Book Reviews: 5.6 pages total; in July, September, and January only.

Managements' Corner: 2.6 pages total; in the September issue only.

Practical Aids: 5.4 pages total; in September and May only.

Problems Department: 2 pages total; in September and May only.

Scrap Box: 2.7 pages total; in July and January only.

ASQC News: 9.5 pages total; in each of the 6 issues.

On the whole, departmental activity in Volume IX was 20 percent under that offered in Volume VIII.

48.5 pages were used to handle Annual Reports, publicity associated with the Sixth and Seventh Annual ASQC Conventions, various publicity items of a miscellaneous nature not conveniently allocable to the News Supplement, and editorials. Less than 10 percent of available non-advertising space went to convention publicity in Volume IX as compared with 12½ percent in Volume VIII. Annual Reports (required by the Constitution to be published each September) again required about 4 percent of the non-advertising space in Volume IX as it did in Volume VIII.

18.3 pages were used for miscellaneous items (covers, masthead, table of contents, and filler material). Volume VIII used 18 pages in this category.

In summary, the only noteworthy differences between Volumes VIII and IX in the matter of how pages published were used is the fact that there was a decided drop in departmental activity with a compensating increase in the total number of papers published.

Qualitatively, the 39 papers appearing in Volume IX may be classified as follows:

General Interest	22
Sampling	3
Management	4
Technical and Semi-Technical	10

A detailed record of income and expense, including *all* publication activities of the Society, is available in the Treasurer's Report (Appendix B).

News Supplement

Editorial supervision of IQC's companion publication continued under the direction of E. H. Robinson during most of the 1952-53 fiscal year. However, direct editorial processing and management of the Supplement was transferred to the Milwaukee office with the October 1952 issue. Thus, as anticipated in this report last year, active responsibility for operations connected with the News Supplement was effectively transferred to George Foster in our Milwaukee office during Vol. 6. A report covering News Supplement experience appears as Appendix G.

Editorial Board Changes

Under the five-year rotation plan governing tenure on the editorial board, three more of the men on the board roster before this plan went into effect left the board as of June 30, 1953. These are: Cecil C. Craig, Joseph M. Juran, and Leslie E. Simon. Replacing these men for a five-year term are Acheson J. Duncan, Paul S. Olmstead, and William R. Pabst, Jr.

The Society is fortunate to have had for so long the loyal and distinguished service of the men who retire this year, and extends its sincere gratitude and good wishes to them. The Society is also fortunate in attracting to its editorial board three such well-known and able men as join its service this year, and welcomes them with sincere pleasure to the task of helping to strengthen and expand Society publication activities.

Reprints for Contributors

The action of the Executive Committee with regard to reprints for contributors on a shared cost basis was described in this report last year. The wisdom of this action has been amply justified by the experience in this area during Volume IX.

During the year 24 orders totaling 9,200 reprints were handled. A little better than 38 percent of the total cost of these reprints was borne by ASQC. It would appear that we have at last found an equitable solution to the problem of meeting the deserving needs of our contributors with respect to separate reprints of their papers for them.

Supplementary ASQC Publications

Yearbook—A 1952-53 Yearbook was published and distributed in April. As with preceding year books of ASQC, this one was likewise assembled and arrangements made for its publication through voluntary effort on the part of officers of the Society. With ASQC at its present size and still growing, this practice can no longer be tolerated. One of the major problems to be solved in the forthcoming year in the publications area of Society activity is that of setting up procedures for transferring the yearbook responsibility to our Milwaukee office and seeking a feasible method of making at least the membership directory feature of this book more flexible and current than it can ever be under the methods thus far used.

Textile Technical Supplement—In August 1952 the Society published the first of a contemplated series of Technical Supplements—the Textile Technical Supplement. These supplements are intended to serve the special needs and interests of the respective Technical Divisions that have or will be created within ASQC. The Textile Supplement very ably met these requirements of the Textile Technical Division, being available for distribution at its conference in Clemson, S. C., August 22-23, 1952.

Distribution of this supplement was membership-wide within ASQC to give our Society an example of one of these publications. Succeeding Technical Supplements, however, will be distributed only within the subject Division, but free copies will be available on request to other ASQC members as per advance notices that will on occasion appear in IQC and the News Supplement.

For the present, at least, control of the editorial content of these supplements resides with an editorial committee of the respective Division concerned. The Editorial Board of ASQC, having no active part in supervising the editorial content of these supplements, accepts no responsibility for them, but endorses their publication and encourages continuation of the policy of making them available to the Technical Divisions under the control of the respective editorial committees concerned.

ASQC Standards, No. 1—The approved report of the Standards Committee, published in the July, 1951 issue of IQC, has now been made into a separate publication with its own special cover design. It stands as the No. 1 issue in the series of reports that will be submitted from time to time by the Standards Committee.

General Publications, No. 1—"Manual on Sampling Inspection by Mil-Std-105A"—The Society has authorized the publication of a series to be known as "General Publications." The No. 1 issue of this series is a manual written by Professor Irving W. Burr at the request of a joint committee of the National Screw Machine Products Association and ASQC. The NSMPA published it first in October, 1952, and ASQC arranged for its re-publication under the Society banner as the No. 1 in its General Publications series.

The character of this manual gives a good clue to the sort of material that will be appropriate for this series. It is not, however, intended that General Publications will be just a series of manuals, but rather that they may provide a medium for the publication of useful material that cannot be accommodated in IQC.

The editorial board will exercise control over material proposed for publication in the General Publication series. These publications will be issued for sale only, and will appear from time to time as suitable material presents itself and resources permit. Publication will, of course, be authorized by the Executive Committee.

Expansion of IQC

During Volume IX pressures developed that made clear the necessity for further expansion of IQC. Plans were prepared and studied for several alternatives for expansion. The ultimate nature of the size and frequency of issue of IQC remains to be determined, but at its Philadelphia Convention meeting the Executive Committee authorized an increase to 64 pages per issue to begin with the September 1953 issue, publication to remain on a bimonthly basis through at least Volume X.

Meanwhile a survey will be undertaken to obtain an expression of opinion from Society membership regarding size and frequency of publication of IQC and other related matters on which it would be helpful to have information from our readers.

Our Milwaukee Office

Under the able and energetic management of George Foster, the operations of the managing editor's office in Milwaukee have moved rapidly forward along the lines set for it a year ago when this office was created by the Society at the Syracuse meetings.

All of the physical operations of getting out an issue have been handled by this office since last September. Manuscripts approved for publication are moved to Milwaukee, scheduled for publication on a priority basis, and used on that basis as nearly as space requirements will permit. Only very general, overall editorial surveillance is exercised in these matters from the editorial chairman's office.

As previously noted in this report, the News Supplement has been handled in whole or in part by the Milwaukee office since October, 1952.

The responsibilities as advertising manager, carried so successfully by Ray Saddoris since 1948, were transferred to George Foster in March, so this very key aspect of our operations is now permanently centered in our managing editor's office.

During Volume IX, arrangements were made with Cuneo Press for direct mailing of each issue without envelopes from a mailing list kept current there by the joint cooperation of our Milwaukee and New York offices. This has resulted in a substantial decrease in mailing costs and an equally substantial increase in the efficiency and ease of mailing operations.

A small inventory of back issues of IQC is maintained in the New York office, but the bulk of back issue inventory is now maintained in Milwaukee. During Volume IX, the managing editor's office set up procedures for keeping a running check on this inventory so that as stock on particular issues begins to run low, arrangements can be made for reprinting to maintain a balanced supply of all back issues.

Procedures have been set up in the Milwaukee office for notifying contributors of the details of their reprint privileges and handling such requests as are made for this service.

The managing editor also now has in force procedures that make it possible to send a contributor galley proofs of his paper before the paper is published. Thus our contributors now have the opportunity of making a final check on their papers as they appear in galley form. This is a service our journal has never consistently had and has long needed.

Preparation of copy for the Index to Volume IX has been handled almost exclusively by the Milwaukee office, only very general supervision of this work being exercised from the editorial chairman's office.

Under our managing editor, the Society now has a single agency devoted exclusively to formulating, integrating, and administering the business and operational details implied by Society policy with regard to publication activity. This office already has been, and will continue increasingly to be, of very real assistance in helping to shape policy decisions in this area. The Society made a wise and timely decision in authorizing and implementing the creation of the post of managing editor last year. In less than one year's time, logical and needed consolidations and improvements have been made. The results thus far achieved have been rewarding. They amply justify the expectation that successful expansion and improvement will be possible along the entire publication front for the Society.

Manuscripts

As this report is written, we have a comfortable backlog of papers approved for publication. Expansion of our journal will, however, have the effect of easing the pressure for publication from the existing backlog and of creating the necessity for continued existence of an ample backlog. What constitutes an "ample" backlog is somewhat of an open question, but it should be noted that on the average it takes a little better than two papers reviewed by a referee to get one to the point of publication. We should have enough approved papers in reserve to keep us consistently two issues ahead of this hurdle. Expansion can seriously threaten safe operation unless there continues to be a steady flow of papers for the attention of the editorial board.

Papers on the ASQC National Convention programs will, of course, continue to supply a significant proportion of the material published in our journal. However, it will be clear to anyone who looks at the publicity notices for the various Section and Regional programs that there is a sizable number of potentially good papers presented on these programs. Far too little of this material is reaching our journal. Program chairmen at the Section and Regional levels could render our journal a real service by seeing to it that challenging material presented on these programs is routed to the editorial chairman's office for consideration by the board. Indeed, this will be a necessity under an expanded IQC, because expansion cannot depend solely on convention programs for its support.

There is also another side to this manuscript backlog situation. Contributors are entitled to be kept much better informed than has been possible in the past of the progress and status of their papers after registering them with the editorial chairman. With the Milwaukee office now carrying the physical workload of producing an issue of IQC, procedures can and will be set up during Volume X in the editorial chairman's office to put this matter of keeping contributors informed on a systematic basis. IQC cannot guarantee to publish *all* the papers sent to it. It cannot even guarantee to publish accepted papers on a *time* priority basis. But it can and will cooperate with its contributors more fully than has been possible in the past in the matter of keeping them informed of the status of their papers.

Conclusion

On the surface, Volume IX of IQC represents somewhat of a plateau in the growth of our journal, being in many respects quite comparable to Volume VIII. Behind the scenes, however, much has been brewing and the stage set for further noteworthy progress, not only in IQC, but all along the Society's publication front. We have a managing editor's office with a year's experience behind it and ready to serve our expanding needs as our publication activity increases. We have an editorial board fully equal to the important responsibilities it must carry in supervising the editorial content of our journal and accessory publications that come under its control. We are developing versatility in our publications activity without sacrificing substance. We can look forward confidently to further satisfying and substantial progress in the forthcoming year. It will be a stimulating experience to have the privilege of working with the Society in this progress.

Respectfully submitted,
MASON E. WESCOTT
Chairman, Editorial Board

New Brunswick, N. J.
Aug. 1, 1953

Appendix G: News Supplement Report

The 1952-53 year has been a most satisfactory one for the News Supplement as well as the Society. The aim of the Supplement—to carry local section news items—was well met this year with, of course, still room for improvement in this direction. A run-down of Vol. 6 shows that most of the sections made a fair number of appearances. Tabulated below is the number of sections appearing in the number of issues specified:

No. of Times of Appearance	No. of Sections
0	4
1	8
2	8
3	11
4	19
5	9
6	7

The plan for Vol. 6 was to print one 4-page issue in August, 1952; four 8-page issues in October, December, February, and April; and one 6-page issue in June for a total of 42 pages. The actual performance for the year was:

Issue	No. of Pages		Quantity	
	Budgeted	Actual	Budgeted	Actual
August	4	4	6500	6400
October	8	8	6800	6500
December	8	6	6500	6600
February	8	8	7500	6300
April	8	8	8000	6900
June	6	4	8500	7500
Totals	42	38		

Also during this year, as noted in the report of the Editorial Chairman, the operation of the News Supplement was transferred from the office of your News Supplement editor, Ernie Robinson, to that of your managing editor, George Foster. The change-over of the mechanical processing was made with the October issue, while the transfer of the editorial work was not completed until the April issue. Since then the complete processing of the News Supplement has been carried on as a regular part of the Publications Office functions.

With Ernie's retirement as editor of the News Supplement this year, a fitting review of his outstanding service to the Society appears in the editorial column on page 3.

For Vol. 7 the plans are to publish the Supplement according to the following schedule:

Issue	No. of Pages	Quantity
August	4	8000
October	8	8300
December	8	7100
February	8	7900
April	8	8600
June	6	8900
Total	42	

However, this schedule is purposely being kept flexible. It is planned that a department will be started in IQC as soon as possible so that Section News items can also be published there. This will probably mean smaller Supplements during the year, but will also mean that the section news can appear every month.

Respectfully Submitted,
ERNIE H. ROBINSON
Editor, News Supplement

GEORGE R. FOSTER
Managing Editor, IQC

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Some Influences of Paper Machine Design and Operation on Variability of Paperboard

CHARLES A. BICKING*
Office Chief of Ordnance

RICHARD T. TRELFA*
Watervliet Paper Co.

UNDER the usual conditions of production, paperboard ordinarily varies widely in basis weight, that is, in the weight of board per unit of area. Experience indicates that this variation may be as high as ± 16 percent of the nominal basis weight and is seldom less than ± 6 percent of the nominal basis weight. These variations can be very considerably reduced by the proper application of statistical quality control.

The use of paperboard is normally based on its area. However, it is purchased on a weight basis. Hence, excessive production of overweight board penalizes the user because of "shrinkage" in area, while excessive production of underweight board penalizes the producer financially, and may penalize the user by impairing other properties of the product.

In the example described here the basis weight variation was reduced approximately 63 percent through the use of simple statistical and engineering analyses.

THE PROBLEM

Customer complaints of excessive variation in weight of paperboard made it imperative for the producer either to control the process or to sort reels prior to shipment. Rather than scrap or down-grade a significant proportion of production, the producer elected to investigate the possible causes of variation and, through an engineering-statistical approach, to determine the most feasible methods for their control.

To assist in visualizing the problem and understanding descriptive terms, a schematic view of a Fourdrinier paper machine is presented in Fig. 1.

As a simplified explanation of paper production, a pulp slurry is metered from the head box through an opening ("slice") onto a moving wire screen where the sheet is formed as water is drained from it, assisted by suction. The wet paper web is "couched" from the Fourdrinier section onto felts. Water is then pressed from the paper by suction presses. The web then passes over steam-heated dryers to complete the removal of water and finally is calendered and wound on reels at the dry end of the paper machine.

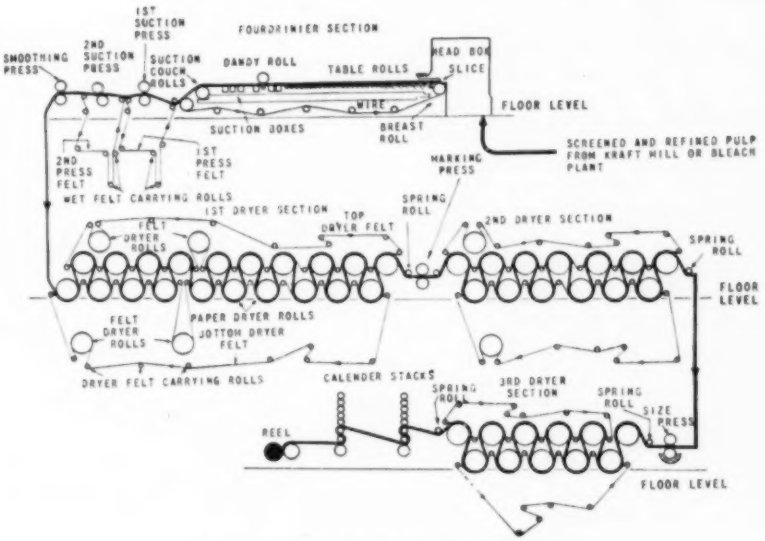

Figure 1—**Fourdrinier Paper Machine**

In addition to the kind of assignable causes usually found in an uncontrolled process, variations in basis weight may be due to long-term process cycles, short-term process cycles, or cycles of intermediate length. Long-term cycles may be concerned with changes in pulp preparation before going to the paper machine, changes in paper machine operator shifts, or other infrequently recurring phenomena. Short-term and intermediate cycles may be caused by such factors as out-of-round rolls, fluctuating head in the head box, pulsating flow through the slice, flow patterns on the wire, and the like. It is apparent, therefore, that different sampling techniques are necessary to identify properly and evaluate each type of cycle.

The "geography" of a reel of paper (or board) is presented in Fig. 2 to assist in visualizing the type of sampling employed.

THE SOLUTION

Long-term Cycles: Reel to Reel Variation. Basis weight of the paperboard in grams per square foot was determined by a composite weighing of ten samples in the cross-machine direction for each

*Formerly with Hercules Powder Company, Wilmington, Delaware.

reel. Control chart techniques were applied to the data to determine the magnitude of machine direction variation.[1, 2, 3]

Two departures were made from the standard Shewhart techniques, as follows:

1. Two sigma control limits were used in the chart for reel average basis weight.

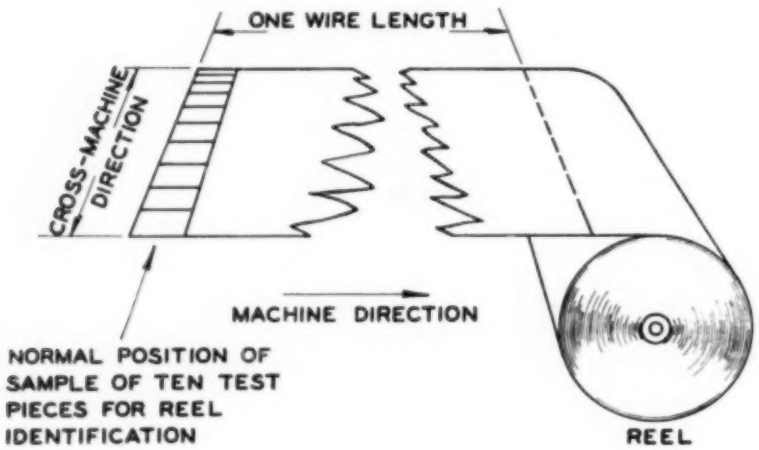

Figure 2—**"Geography" of a Reel**

2. Control chart limits for reel averages were calculated from moving ranges; i. e., the differences between successive reel averages.[1, 2]

The reasons for these departures are as follows:

1. When making one set of measurements per reel, each set is spaced so far from the next and represents so much intervening product that some extraneous factors are included when using the Shewhart techniques. The authors have found that in many practical applications the use of two sigma limits minimizes the effect of these extraneous factors.
2. The use of moving range permits most efficient use of the data available.[4]

Also, in the study presented here, the control limits do not have the significance asociated with the 3-σ control limits computed by the Shewhart techniques because of the definite cycling revealed and because of the undetermined character of the populations sampled. Regardless, such control chart calculations, whether or not satisfactory for production control, do afford a simple, rapid procedure for estimating sample variations. If used consistently, they provide a valid basis for comparing magnitudes of various sources of variability.

A control chart for reel average basis weight (from composite weighing of ten samples in the cross-machine direction) is shown in the chart of Fig. 3.

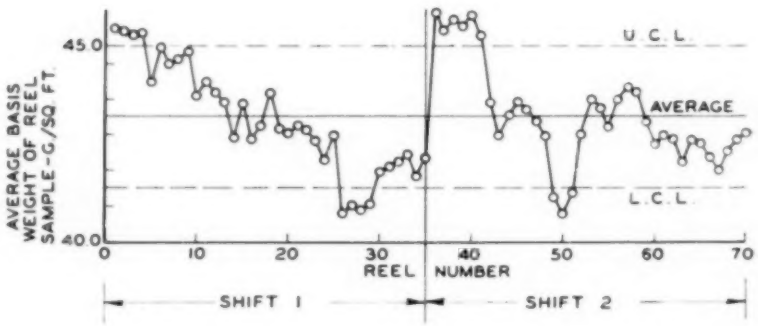

Figure 3—**Reel Average Basis Weight**

As the control chart for reel averages was continued, it was established that the shift cycle observed in Fig. 3 was consistent. Causes were indicated by the control chart and confirmed in the subsequent educational program. Output and quality of paperboard were judged on a shift average basis. When an operator at the start of a shift found production below the nominal basis weight, he would adjust the machine. Usually he would overadjust and the basis weight of production would rise well above the nominal value. For the remainder of the shift, attempts would be made to bring basis weight for the shift back to the right average, causing an overall drift back to a level below the nominal.

The educational program, regular use of control charts, and installation of improved control equipment all contributed to minimizing these shift cycles.

Short-Term Cycles: Within-Reel and Within-Wire-Length Variations. To detect short-term cycles, a special sample the length of the Fourdrinier wire, 70 ft., was taken from a reel. The sample was cut into strips having a length equal to the full cross-machine width (135 in.) and a width (12.5 in.) which was a simple fraction of the circumference of the smallest roll on the paper machine. The strips (68 of them for the 70-ft wire length) were weighed individually, control limits were calculated, and the data were plotted as shown in Fig. 4.

From the data of Fig. 4 and subsequent replication of the experiment, it was apparent that at least two short-term cycles of measur-

able size affected the basis weight of the paperboard.

The shorter cycle repeated approximately every 50 in. and the longer approximately every 10 ft. The 50-in. cycle corresponded to the circumference of the smallest (16 in. diameter) rolls on the machine, and subsequent reconditioning of these rolls eliminated this cycle. The longer 10 ft. cycle did not correspond to the circumference of any roll and, therefore, was considered probably

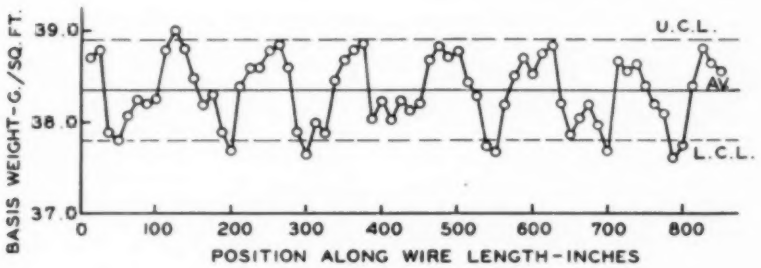

Figure 4—**Basis Weight Variation Within One Wire Length**

due to pulsating flow from the head box or variation in wire speed. This cycle was minimized by simple measures, including a minor change in the head box and the adoption of a procedure for throttling the pumps for pulp slurry feed and white water (water drained through the wire in forming sheet). Although the effect of these cycles was small compared to effects of long-term cycles and between-reel variation, such cycles could contribute appreciably to basis weight fluctuations when several cycles were temporarily in phase.

Intermediate Cycles: Within-Reel Variation. Since cycles had been detected from reel to reel and within a wire length, the next step was to check for cycling between wire lengths. Accordingly, 70-ft. (wire length) samples were taken sequentially from a reel of paper. A strip the full cross-machine width, 135 in., and 132 in. long was taken from each of 35 consecutive wire-length samples and basis weight was determined. The 132-in. length was chosen to minimize the effects of the short-term cycles. As a further precaution, strips were cut from each wire length in a random manner.

Control chart techniques were applied to the basis weight data and results were plotted as shown in Fig. 5. From Fig. 5 it will be noted that:

1. there is a cycle which peaks approximately every five wire lengths (every 350 ft.),
2. a slight upward trend exists throughout the reel, and
3. control limit spread (1.1 lb.) is the same as calculated for within-one-wire-length variation (Fig. 4), indicating that these variations are of the same order of magnitude.

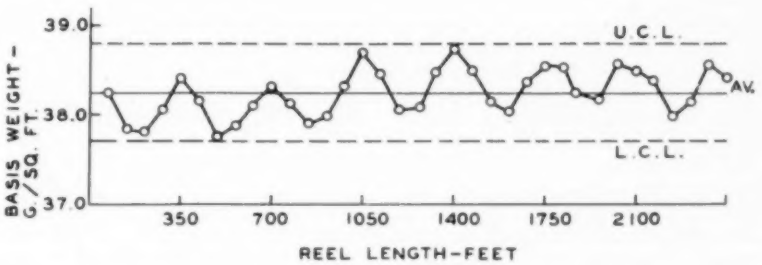

Figure 5—**Basis Weight Variation Within One Reel**
(Points are wire lengths)

While no satisfactory explanation of the cycle was apparent, the corrective measures taken for elimination of short-term cycles also minimized this 350 ft. cycle. The upward trend noted undoubtedly indicates a gradual change in basis weight which is contributing to variation among reels.

THE RESULTS

1. Sources of basis weight variation were clearly recognized and were, therefore, subject to more efficient engineering study.
2. Corrective measures, including education and minor machine changes reduced paper variation in a six month's period from ± 6.3 percent of nominal basis weight to ± 2.3 percent of the nominal basis weight.
3. Mill management recognized the merit of statistical techniques and initiated an overall statistical quality control program.

THE CONCLUSION

The use of statistical techniques in combination with engineering analysis of the papermaking process can provide specific answers to problems long considered part of the "art" of papermaking.

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A Survey and Evaluation of Types of Quality Control Education*

JOHN A. HENRY

University of Illinois

THE opportunities for education and training in quality control have developed hand in hand with the acceptance of the art as a management tool. Indeed, quality control may be unique in the area of scientific management because in many cases acceptance has been the direct result of formal training rather than the reverse. It is the purpose of this article to review the present development of training and education, and to raise some questions about what the future shall be, and in particular, what part the American Society for Quality Control shall play in that future.

It must be remembered that the pioneer work in this field followed the tradition of slow development and acceptance. The work done in the 20's at the Bell Telephone Laboratories by Dodge and Romig[1] and Shewhart[2] in the first approach to scientific sampling and the invention of the control chart can scarcely be said to have taken American Industry by storm. By 1940 there were probably not more than a score of the larger companies which had personnel interested in these ideas. With World War II came the series of federally sponsored training activities for industry culminating in the Engineering, Scientific and Management War Training programs, offered in cooperation with schools and colleges throughout the country. Under the Office of Production Research and Development, War Production Board, a Quality Control Section was set up under the direction of Dr. Holbrook Working of Leland Stanford University and Dr. Edwin G. Olds of the Carnegie Institute of Technology.[3] Thirty-four of the famous "eight-day courses" were given from coast to coast, and 1885 men from over 900 organizations took part. An equal number attended the special one-day opening or promotional parts of the program.

*Paper presented on the program of the Sixth Annual Convention of ASQC in Syracuse, New York, May 1952.

This venture in training served two useful purposes. Hundreds of industrial firms made immediate applications of the principles learned and saved the American taxpayer countless millions of dollars. Of more permanent significance was the creation of local quality control groups and societies by the graduates of the eight-day sessions. The American Society for Quality Control was formed by the union of these scattered groups, so it can be truly said that the Society was founded on an educational base. As a professional society its primary function is the encouragement and dissemination of knowledge. The three committees of the Society having this as their main function are the Editorial Board, the Brumbaugh Award Committee, and the Committee on Education and Training. Every Sectional meeting, Regional conference and National convention is an adventure in learning.

How are we doing with this training job? At present we have several regularly scheduled training programs sponsored by universities, evening programs sponsored by colleges and local sections of the Society, conference quickies, promotional meetings, in-plant training programs, a flood of books and articles, and a trickle of college-trained men. Have we a right to be satisfied?

INTENSIVE SHORT COURSES

The half dozen ten-day training programs sponsored annually by various universities are outgrowths of the war-time ESMWT programs. They attempt to present the principles behind control charts and acceptance sampling, to give some practice in the mechanics of these tools, and to explore the practical problems encountered in the administration of them. Early this year a correspondent asked if he could reasonably expect to become an expert, in the sense of a consultant, by taking one of these programs. The answer is obviously and emphatically "No." No one becomes an expert in any field by taking a course or series of courses, and all that these short courses can hope to do is to give a man enough of a start so that he may begin to practice on a sound basis and by continuing to study and practice, finally develop into a reasonable competence if not into an authority. This is a statement, not a criticism. What can we expect of ten days and the average person—one might say even the superior person? The strong points of these programs are many. They are generally well organized and taught by well qualified personnel. Once embarked, the student finds he is not distracted by other problems, nor indeed does he have much time for them. The basic principles, upon which a plant program swims or sinks, are carefully presented, drilled and reviewed. Because they carry a fee and in most cases involve absence from the home plant, it can be hoped that management sends properly qualified men, both by background and position, to take advantage of them.

On the negative side, it is true that while the basic principles are few and well presented, they come rather fast for all but the trained student to grasp, and it is plant personnel, not students who must put them into use. This means that the course must be followed by some form of review and study. It may also be argued that these courses are so far from the home plant that they lack reality, but this objection is more than balanced by the exchange of ideas between the various students, and with the instructors.

The same arguments can be advanced in behalf of or against the few "advanced" courses offered, which generally take up a review of the basic material, plus work in the fields of correlation analysis, significance testing, and design of experiments.

EVENING SESSIONS

In a majority of the industrial centers of the country evening sessions

are offered by colleges, technical schools, local sections of the ASQC, and other sponsors. They may be credit or non-credit, free or on a tuition basis, and may run from 8 to 16 two-hour sessions. The advantages are obvious. They can be attended by persons who could not go out of town, and they provide for a period of rest and reflection between doses of theory and class room discussion. They are likely to be staffed by adequate instructors, and follow in general the outlines of the ten-day programs.

On the unfavorable side, the opportunity for reflection and study is apt to be neglected, unless the course is credit bearing. Many "practical" persons may be repelled at the first sign of theory, and drop out before the application is thoroughly reviewed and developed. This may in part be overcome by proper arrangement of the topics. To be honest, this weeding out process may be a real advantage both to the individual and to his company. A major weakness is the usual lack of a laboratory session, in which the principles and practice are actually used by the student under instructional supervision.

ONE- AND TWO-DAY SESSIONS

If an expert cannot be developed in ten days, the "quickies" must fall short of the level of competence. They do serve a very real and useful purpose. They may be utilized as a brief but effective supplement to personal coaching, and as an excellent promotional device for the top executive who cannot or will not attend a longer course. Many who attend such a program, usually sponsored by the Society at the national, regional or local level, are stimulated to participation in a longer session. On the other hand, a person who has taken the full dress program will sometimes attend the shortened version for review purposes. Such persons invariably comment on the ability of the instructors, an excellent testimony to their own growth and development.

THE IN-PLANT PROGRAM

Because of the variety of purposes, methods, lengths and instructional abilities, the in-plant program is difficult to discuss. As we get close to the actual scene of operation of a quality control program, we see more clearly the need for different levels of training and approach. A manager or director of quality control should ideally be an educated, not a trained man. He should thoroughly understand the technology of his industry; he should understand the problems of production and inspection, and should appreciate and practice the scientific evaluation of data by statistical and other methods. The in-plant course is not for him, unless he is to be the instructor or coordinator.

Top management needs an overall idea of the principles, such that intelligent decisions can be rendered on the evidence marshalled by the quality control staff. While a base can be laid at the "quickie" sessions, only practice and persistence will lead to assimilation of these techniques into the personality of management. The average president or production manager would profit by actually pushing a pencil, calculating and interpreting these useful aids to judgment.

The bulk of training in the plant will be pointed to the quality control and inspection personnel, to the production foreman and his aids, the standards and methods men. About eight hours is enough for the average foreman. If he wants and takes more he is probably a good bet for a higher supervisory position. The rank and file of the inspection and quality control people of whatever title and rank should get the works. This helps to provide capable men for their immediate jobs; it also serves as a guidepost for promotion. Interest and talent is found in the most unexpected places.

Finally, it can be argued that the indoctrination of new personnel at all levels should include a well prepared explanation of the economic importance of quality, the place of the newcomer in this quality program, and an explanation of the techniques actually used in the plant for quality protection. Needless to say this indoctrination will be futile unless management practices what it is preaching.

EDUCATION AT THE COLLEGE LEVEL

A review of this training and educational problem would not be complete without a look at the college student. Dr. Olds, in a companion paper[4] presents the case of the engineering student, and I shall not dwell on that, except to venture a guess that here is the cradle of the quality manager of tomorrow. Four years ago the Committee on Education and Training[5] found 35 engineering colleges out of about 130 offering some work in quality control, and a somewhat larger group offering courses in statistics. The word "offering" is used advisedly. In the writer's own institution, out of a total of approximately 900 graduating seniors in 1951 about 43 took courses in quality control and practically none in statistics.

What shall be done for the men in the management courses in colleges of commerce? And what about the mathematicians? We must have a steady supply of theoretical statisticians who are willing and able to help us find new solutions to our problems. Some of these men will find a place in the larger industrial organizations, while others will locate in the colleges and in research organizations.

SCOPE OF TRAINING AND EDUCATION

Up to this point, little has been said about what constitutes an adequate background for general quality control work aside from statistical procedures. Blueprint reading, contracts and specifications, inspection procedures, test codes, functional design and personnel relations must all be understood by the capable quality control man. As a Society, we cannot assume responsibility for all these factors, nor for all the skills and knowledge that the general factory personnel must possess to do a quality job. There are some general principles that we must stand for.

All supervision, including sales and purchasing, must appreciate the philosophy of the calculated risk, with sufficient understanding to accept the judgment of the statistically trained quality control man. Supervision must understand that quality is the responsibility of the design and production forces, and that the act of inspection does nothing in itself to make a satisfactory product. Quality control recommends; action must be taken by engineering and production.

This leaves plenty for quality control to contend with. At the level of action, there is the evaluation of product and process quality, and active aid toward the corrective action. Inspection equipment and procedures must be accurately and hon-

estly evaluated. The following list of topics is a minimum that the quality control man must really understand:

1. The idea of variation and its measurement, and the concept of random and assignable causes.

2. The relation between the variation of averages and individuals, and the proper comparison of process capability to specification tolerances.

3. The meaning and calculation of the operating characteristic curve, the average outgoing quality curve, and the average sample number. He *must* learn to judge the economic effects of any sampling plan, whether it be rule of thumb, taken from a published set of tables, or tailor-made on a scientific basis.

4. The scientific comparison of methods or processes.

5. The measurement of effectiveness of substitute tests.

6. The translation of his technical skills into the universal langauge of the dollar.

It should not seem necessary to make up such a list, but the slow progress or outright failure of many promising quality control programs can be traced directly to the quality manager who does not understand or does not believe in these principles. He sacrifices logic for guesswork, hard mental calculation for speed, and in the end he sacrifies all.

CONCLUSION

We are back to the original question. Are we satisfied with the opportunities and the methods of our present training? Do our in-plant programs and external courses give us what we want and need? This paper presents nothing new, but merely points up some problems for discussion. Some of the problems may never be solved, but if answers to a few can be obtained the search will be worthwhile.

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Quality Control As a Methods Improvement Function In Automotive and Aircraft Parts Manufacturing*

E. F. GIBIAN
Thompson Products, Inc.

STATISTICAL Quality Control has spread widely through the industry of the United States, and now as is loses some of the glamour always associated with a new science or technique, it is gaining in the intensity of its development and application. *Statistical Quality Control has come of age.* It therefore appears appropriate to pause and take stock! Where do we stand and where do we go from here?

The Automotive Technical Committee has set up this program to discuss quality control aspects of particular interest to the manufacturers of parts and subassemblies. The J-35 Allison jet engine is one sample of the aeronautical products for which we manufacture parts, components, subassemblies, and accessories involving difficult materials and high precision. SQC procedures in receiving, manufacturing, and inspection of automotive and aircraft products have been used for about eight years, and the experience thus gained, together with a few simple examples from our practices, will serve as a framework for suggesting the answer to the question, "Where do we stand and where do we go from here?"

In appraising the present status of SQC in industry, particularly in the automotive and aircraft field, a fundamental weakness appears to be its limited scope of application. In turn, this limited scope may be the result of the organizational set-up under which this function is being administered in most plants. Not counting a few notable exceptions, SQC has grown up as an adjunct to the inspection function and has remained there, its use being limited mainly to watching over the quality and signaling either compliance or non-compliance with specifications by means of control charts and sampling tables.

Thus, SQC has been utilized as a weapon of defense against waste, mistakes, and carelessness, its avowed purpose being advertised as a means of quality improvement, or, to quote verbatim from the prospectus of the Fifth Annual Convention, "Quality Control by statistical methods is an established tool for improving and maintaining quality standards." That describes exactly the point where we stand today.

Now an army equipped with modern tanks may occasionally use these tools of warfare to good advantage for defense purposes, but their principal value lies in their mobility and offensive ability to lead an attack. Similarly, SQC is a tool of industry which can be used for attack, an analytical means for attacking all sorts of industrial problems and

*Paper presented on the program of the Fifth Annual Convention of ASQC in Cleveland, Ohio, May, 1951.

bringing about improvements in the entire production process. Up to now, SQC has been almost exclusively a vehicle for deductive thinking. The time has come to turn to inductive, creative thinking, to broaden the base of SQC, to apply it to process and management controls —in other words, to let it serve the broader function of methods improvement.

This concept of the function of SQC may be a controversial point, but companies which organized quality control programs on this basis produced remarkable results. The use of statistical methods in quality is only one of the many fields of application. Equal emphasis should be given to statistical analysis in search of improved production processes, time study and standards engineering procedures, tooling improvements, inventory control, cost control, personnel management, and all other activities where chance variations influence the results. SQC engineers should be ready and able to serve the entire organization and all departments.

As long as SQC is considered a tool for improving and maintaining quality standards, it is quite natural to assign the administration of these statistical methods to the quality manager or chief inspector. This is the conventional type of organization prevailing in most plants. To avoid any misunderstanding, this is no adverse criticism of such an organizational set-up. In fact, the excellent results in quality improvements and in economies of inspection at numerous plants amply demonstrate the valuable achievements obtained where competent inspection personnel undertook the application of SQC procedures. But if we accept the contention that statistical control methods are profitably applied to the broader field of methods improvement, not limited to the area within the jurisdiction of the quality manager and chief inspector, then we have to create a different organization for the administration of the SQC program.

In the larger Thompson plants—by way of example—the administration of statistical control procedures is assigned to the Statistical Control Department reporting to the division industrial engineer. This department is essentially a service department with the responsibility to conduct research and develop improved methods wherever statistical techniques may be applied. These statistical control engineers are members of the industrial engineering team, in which are integrated the functions of standards engineering, job evaluation, budgetary and manpower controls, methods engineering, and plant layout. In turn, all Division Industrial Engineering Departments are governed by the policies and procedures established in the Staff Industrial Engineering Department under the direction of the Chief Industrial Engineer, whose staff of specialists includes also a staff statistician. This staff statistician not only acts as consultant to the divisions' statistical control engineers; but he also directs the training of statistical personnel, designs and, if necessary, conducts initial training classes for operating supervisors, including plant managers, inspectors, and technical personnel; and of course acts as a focal point for the exchange of information and the dissemination of significant developments in techniques and new applications.

Under such a set-up, the introduction of SQC to inspection procedures is handled by the Statistical Control Department, just as any other type of methods improvement. Of course, the quality manager or the chief inspector and his corps of inspection

THIS COPY TO DEPT. — TO: STATISTICAL CONTROL DEPARTMENT

COMPLAINT RECORD — NO. 53

ORIGINATED BY:	GENERAL FOREMAN'S APPROVAL	DEPT. NO.	DATE
Lemak	C. W. Anspach	611	1-24-51

PART NAME: Stator Blade — CUSTOMER'S PART NO.: 6301 - 9L8278L; 6301-1 - 9L9604L; 6301-2 - 9451762 — F.R.: 6301-4

COMPLAINT:

Leading Edge of O.D. on blade has a dip in it which causes trouble in sizing the blade.

This condition is caused by forge shop.

18435 also has same dip in it.
6071 also has same dip in it only on "I.D." of blade
6077 has same dip

INVESTIGATED LOCALLY — DATE	ASSIGNED TO ENGINEERING — DATE	ASSIGNED TO LABORATORY — DATE
1-26-51	1-30-51	

ADJUSTMENT:

Study of control charts, die records, and inspection data show that width of sizing die pads is the direct cause of this trouble. Engineering is opening up pads as shown on attached sketch. First experimental die tried out on FR6301-4 produced good pieces.

INVESTIGATOR	ISSUE DATE	DEPARTMENT HEAD
to follow up K. V. Ward	2-6-51	W. H. Coughlin

Figure 1—**An Example of the Form Used for Processing Requests for Investigations**

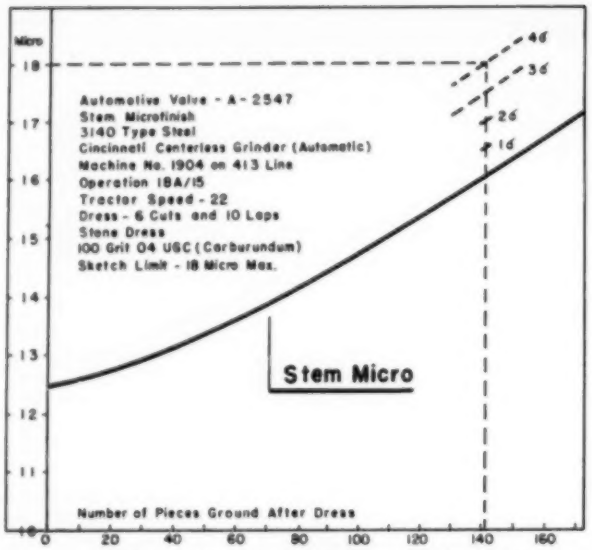

Figure 2—**Determination of Optimum Wheel Dressing Cycle**

personnel have acquired the knowledge of statistical control principles, but they rely upon the craftsmanship of statistical control engineers to develop control charts, sampling schemes, and quality audit techniques, just as the plant manager and his foremen rely on specialists, methods engineers, to furnish them with improved manufacturing and material handling processes. The SQC program, while designed and constantly improved by the statistical control specialists, is operated by the inspection personnel, and this mutual interplay of interests is no doubt the main factor for the dynamic growth of the statistical control program in our organization.

Control engineers, not burdened with the day-by-day pressure of the inspection operating task, are in the advantageous position to apply their knowledge to a broader field which is of utmost importance to a progressive plant management, particularly in the precision manufacture of parts and subassemblies. This expansion of statistical control techniques beyond the limited scope of quality control proper leads into methods improvements of processes and procedures which would otherwise be difficult to achieve without such a group of specialists expressly organized and trained for that purpose. This is where initiative and inductive thinking come into play.

Yet, there is one more condition which has to be met to create a favorable climate for this concept of SQC applications and to insure its vitality and growth. An understanding of fundamentals, principles, and basic techniques of SQC must be imparted to factory supervision from the management down to foremen and supervisors, to department heads, engineers, technicians, accountants, purchasing agents, and personnel supervisors.

This training, by means of carefully planned elementary courses, which incidentally can be made quite lively and entertaining, is far from formidable. A description of such a training program would exceed the scope of this discussion, but let it be said at least that this honest-to-goodness training in fundamentals is less costly and more effective than the sometimes encountered abortive schemes of promoting SQC by ballyhoo, posters, cartoons, and advertising a la singing commercials. The informed supervisor, while not a statistical technician, will sense where statistical procedures may help to solve his problems and will promptly present them to the control engineers. This is exactly what is happening in our plants, and such terms as frequency distribution, range, three sigma limits etc., are part of many a supervisor's vocabulary. There is no doubt that this wide-spread use and knowledge of SQC applications contributes to the quality and methods improvement mindedness of an entire organization.

SQC as a methods improvement function is practiced in a number of companies. It is a natural development of the art, neither originated in nor limited to the Thompson Products' plants. But, for purposes of illustration, a few examples from our practices are presented. They have been selected because of their simplicity so they may be readily understandable to those whose experience in SQC is of an elemental nature.

Written requests to the Statistical Control Department to investigate "complaints" and their disposition are recorded on the form illustrated in Fig. 1. A supervisor from any department of the plant may originate such a request. The written

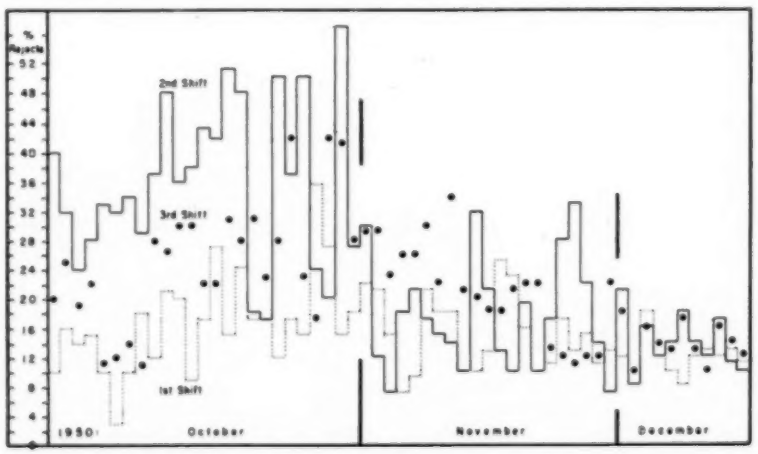

Figure 3—**Percent of Visual Defects by Shift from Oct. 1 to Dec. 14, 1950** (20x Binocular Inspection HJ-4102 Bucket)

request is first analyzed to determine whether it justifies investigation by a QC engineer, or whether it should be handled by some other party. If the complaint warrants investigation, a number is given to the request, and the handling of the case is assigned to a QC engineer. He may be able to work out the solution by himself, or he may engage the services of the Engineering Department or the Laboratory.

After the case is finished, a completed "complaint record" showing the complaint and the action taken is issued and forwarded to the originator, interested members of the supervision, the quality manager, the product engineer, the division industrial engineer, and the division manager. All information and data pertinent to the investigation are permanently filed in the Statistical Control Department. Many methods improvements result from such a procedure, the case covered by the illustration being a typical example.

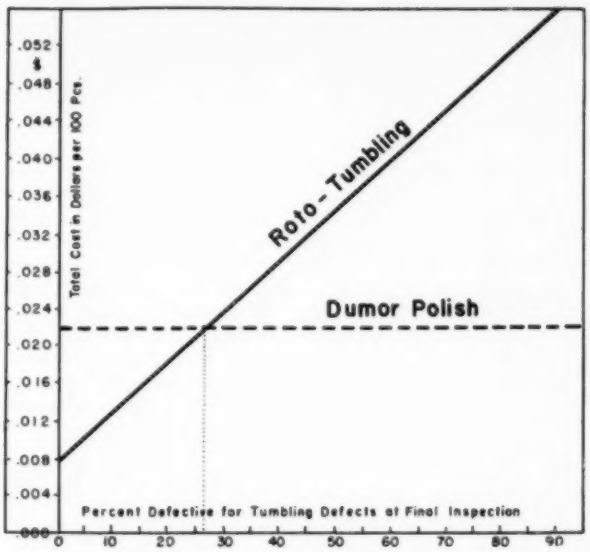

Figure 4—**Study of Cost Relations Between Two Finishing Methods**

The second example, Fig. 2, is the result of a study undertaken upon the request of a time study supervisor, to determine the number of valves that can be finish ground on the stem within the specified finish tolerances on one dressing of the grinding wheel. The chart represents a condensation of the findings collected from measurements made under controlled conditions at various grinding wheel diameters from the time the wheel was new until it was dressed down to the smallest useful size. The micro-finish readings of the valve stems were plotted, the curve shown on the chart being the statistically derived correlation between surface finish and number of pieces per dress, with practically all of the readings within $\pm 3\ \sigma$ limits. The upper $4\ \sigma$ limit was adopted as a safe basis for computing the wheel dressing allowance as well as a guide for the operator. For instance, to insure a maximum finish of 18 microinches, the grinding wheel is to be dressed every 142 pieces.

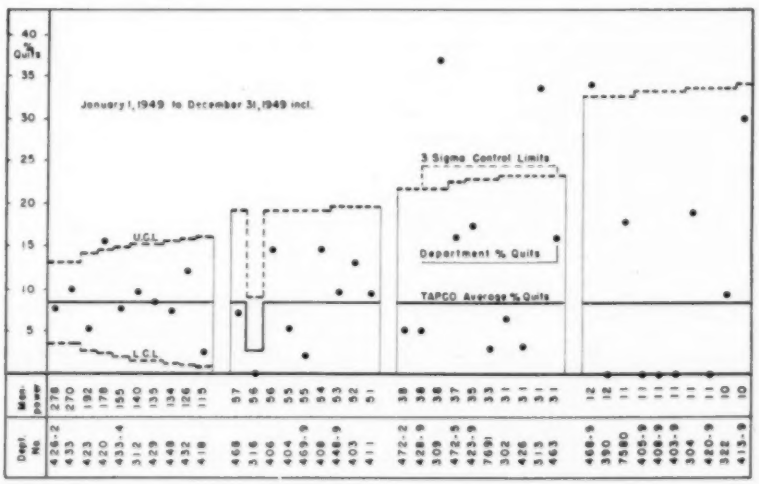

Figure 5—**Analysis of Tapco Quits** (Hourly-Rated Personnel)

Control of visual inspection applied to precision aircraft parts is a difficult task because measureable quality standards cannot be set for many critical characteristics, acceptance or rejection being largely governed by the subjective judgment of the individual inspector. The chart in Fig. 3 gives the history of a case where variations in visual standards between shifts were analyzed by a statistical control engineer and eventually eliminated. The example deals with the visual inspection, under a twenty magnification binocular, of a turbine bucket for such defects as surface finish blemishes, nicks, scratches, pits, and imperfect blends.

Samples of pieces not passing inspection were taken from each shift and were reinspected by the inspection foreman to determine how stringently each shift was adhering to the visual standards specification. It was soon evident that the second shift was too critical and rejected or sent back acceptable pieces for repair and rework. With these data on hand, it was possible to institute the necessary corrective steps. Visual inspection standards were more clearly defined and the second shift inspection supervisor and his inspectors were given proper instructions. The chart shows clearly how the cooperation between the Inspection Department and the Control Department eventually brought

about a uniform inspection level among all three shifts.

How statistical control engineers may participate in cost control decisions is illustrated by the simple example of Fig. 4. Jet engine compressor blades were wet tumbled to clean out the fillet in the areas forming the transition from the airfoil to the root, this cleaning operation being necessary in order to obtain reliable indications in the subsequent magnaflux inspection. This tumbling operation always produces a certain percentage of nicked or scratched blades which have to be repaired. The repairs add to the manufacturing cost of this tumbling process, increasing with the percentage of nicked blades, as shown on the chart. An alternate process of cleaning the fillet surfaces by a polishing operation may be employed, its cost per 100 pieces remaining constant because no repairs occur.

Quality records were maintained for each type of blade, tabulating the average percentage of blades rejected for nicks and scratches in tumbling. The chart was prepared by the Statistical Control Department to show that it is more economical to replace tumbling by polishing when the percentage of blades rejected in tumbling exceeded 26%.

At the same time, the control engineer instituted a thorough study of the tumbling process, employing control charts to determine the effect of tumbling speeds, loads, cleaning agents, and other variables upon the amount of nicks and scratches. Improvements in the tumbling operation were thus accomplished, lowering the amount of nicks and scratches, but the chart still holds good as a criterion for deciding when to tumble and when to polish.

The Personnel Department turned to our statistical control engineer for a departmental analysis of the labor turnover. A modified "p" chart, reproduced in an abbreviated form in Fig. 5, put the spotlight on a few departments where the percentage of "quits" exceeded the control limit based on the plant average. Surprisingly enough, an investigation of these departments by the personnel manager brought out a suspected assignable cause—the faulty administration of personnel practices by the department foreman or supervisor. It was easily corrected by the proper instruction of these men.

The examples discussed here were chosen to illustrate the potential broader function of SQC, reaching beyond the conventional quality applications. More complicated cases could have been given to show how statistical investigations led to partial or complete redesigns of fixtures and entire machine tools; how foundations and mountings of precision tools were altered to keep the process under control; how layouts of production lines were planned to accommodate AOQL continuous production sampling inspection; how a statistical study led to the development of a precision forging process for automotive valves effecting economies in subsequent machining operations; how ratio delay determination through random observations and control chart techniques gave time study standards more reliably and economically than conventional methods.

The Statistical Control Engineer in the precision manufacturing industry can render a greater service by applying Statistical Quality Control techniques to methods improvements!

The Use of Statistics in Food Processing

STEPHEN HARRISON

Research Laboratories, Kraft Foods Company

THE progress of statistical thinking and statistical quality control in the food industry so far has not been striking. In seeking a reason for this, it is natural to ask if there are special characteristics inherent in food processing which make effective statistical applications difficult.

What are the special features of food processing? From our point of view, the most obvious characteristic is *high variability*.

1. *Variability of Raw Materials*

The raw materials of the food industry are almost entirely of biological origin, so it is not surprising that they display the fundamental biological property of variation. Those who have worked for years with a particular food product will tell you that they still get surprises regarding the nature and behavior of their raw materials—the variety is apparently endless. Apposite is the saying so often heard in the dairy industry: "Every day's a new day in the milk business."

2. *Variability of the Process*

Very small changes in the processing variables often cause very large changes in the final product; e.g., the drying of tapioca starch gel or the preparation of enrobing chocolate with just the right physical characteristics.

3. *Variability of Evaluation Techniques*

Evaluation techniques in the food industry present something of a problem. Some types of estimation are relatively precise; e.g., the determination of refractometric solids. Many procedures, however, involving chemical analyses or complex empirical instrumentation are typically not very precise. This applies also to bacteriological procedures and biological assays. Quite often the techniques themselves are controversial; for example, the problem of deciding just how relevant are different techniques for measuring the physical prop-

erties of gel-formers like agars and gelatins. Perhaps most difficult of all is the evaluation of the organoleptic quality of the products.

Not only do many of these techniques lack precision, they are often time consuming—obviously an important consideration from the point of view of on-the-spot quality control.

The writer does not believe that these characteristics of food processing in any way exclude the application of statistical quality control. It seems likely, though, that methods worked out principally in the engineering industries will need a little modification and interpretation before they will "fit" the food industry.

The statistical approach to quality control in the food industry is considered here under four headings; weight control, chemical composition, physical properties and organoleptic properties.

WEIGHT CONTROL

The weights of packages or units of a food product leaving the filling machine do exhibit, of course, a certain degree of variation and a distribution which are characteristic of that particular machine and process.

It is customary in statistical quality control to distinguish between non-assignable and assignable causes of variation. The non-assignable are those irreducible random causes of variation inherent in the process and for which no adjustments can be made, short of modifying the design of the process. A process showing only these variations is said to be in control. Assignable causes of a specific nature are those which introduce additional variation into the process over and above the background variation. The function of the quality control chart is to distinguish between these two kinds of causes of variation, that is to say, to tell us when an assignable cause has made its appearance so that we can either eliminate the cause or adjust the process in some way so as to neutralize its effect.

In food processing, assignable and non-assignable causes of variation grade into one another in a disconcerting fashion. Between the two extremes lies a broad penumbra of doubtful cases. For this reason, we have been led to *redefine* the notion of assignable cause for our own private purposes in a way which is of greater operational value. For us, an assignable cause is one which produces its effect *long enough* for it to be worth-while making a compensating adjustment to the filling machine. By "long enough" we mean that the period of operation of the cause is longer than the intersampling period; i.e., the time interval between successive check-weight samples.

This leads us at once to the question of how we ought to arrive at our estimate of the error variance upon which to base our control limits. This is usually done by taking a series (say, around 50) of small groups of samples, then determining the mean within-group variance. How should we space our sampling of the items within each group? Grant[1] offers us two alternatives; either sampling *contiguous* individuals or sampling *randomly* within an agreed time interval—say 15-20 min.

We have tried the experiment of spacing the sampling of individuals within groups over different periods of time, then plotting the within-group standard deviations against the interval over which the individuals were sampled in each set of groups. The smallest expected variance should be that based upon the squaring of successive differences where the individuals within each group are contiguous—that is, next to one another on the production line

$$s^2 = \frac{\sum_{j=1}^{m} \sum_{i=1}^{n-1} [\, x_{ij} - x_{(i+1)j} \,]^2}{2m\,(n-1)}$$

where n is the number of individuals in each group and m is the number of groups.

The next variance calculated was based upon the same groups of contiguous individuals as employed for the above successive difference variance, only calculated in the normal way

$$s^2 = \frac{\sum_{j=1}^{m} \sum_{i=1}^{n} (x_{ij} - \bar{x}_j)^2}{mn}$$

Five other mean within-group variances were calculated, the individuals within each group not being contiguous but spaced randomly over a certain time interval. This interval was, respectively, 0.4, 2.1, 5.0, 9.5 and 100 hr.

These sample variances were converted to unbiased estimates of the corresponding population standard deviations and are shown plotted on Fig. 1. A smooth curve has been fitted by eye.

As expected, the mean squared successive difference estimate was the smallest. The population variance corresponding to this estimate would not *necessarily* be the smallest of the various within-groups population variances, since it could be inflated by a short-term negative correlation effect, but we have not so far observed this situation.

We decided that it would be desirable to take regular production samples for check-weighing every 15 min. since this would give the check-weigher time to supervise several lines. Reading from Fig. 1 for an interval of 15 min. (0.25 hr.) gives an s.d. value of 1.15. We based our estimate of the control limits for averages upon this. The difference between this standard deviation and the maximum (asymptotic) value shown in Fig. 1 measures the maximum amount of weight variation which can be eliminated by this scheme of quality control. The extent to which this goal can be realized depends partly upon the extent to which this residual variation occurs as long-term trends. In the great majority of instances known to the writer, this tends to be the case.

We selected our intersampling period of 15 min. in this instance, since this was the best which could be done with the available personnel. Actually, of course, we could have treated this more rigorously. The more frequently check-samples are taken, the smaller the s.d. upon which control limits are based. This means that the mean package weight can be allowed to approach the legal minimum a little more closely with consequent savings in materials. But more frequent sampling increases the cost of our quality control program. By graphical methods it would not be difficult to determine the optimum point giving the frequency of sampling which minimizes cost. In this case, it hardly seemed worthwhile, since the slope of the line in Fig. 1 in the region of our selected sampling period of 15 min. is not at all steep so that large changes in inspection rate would produce only small changes in the spacing of the control limits. For example, doubling the inspection rate in our case would reduce the s.d. upon which control limits are based by only 8-9 percent.

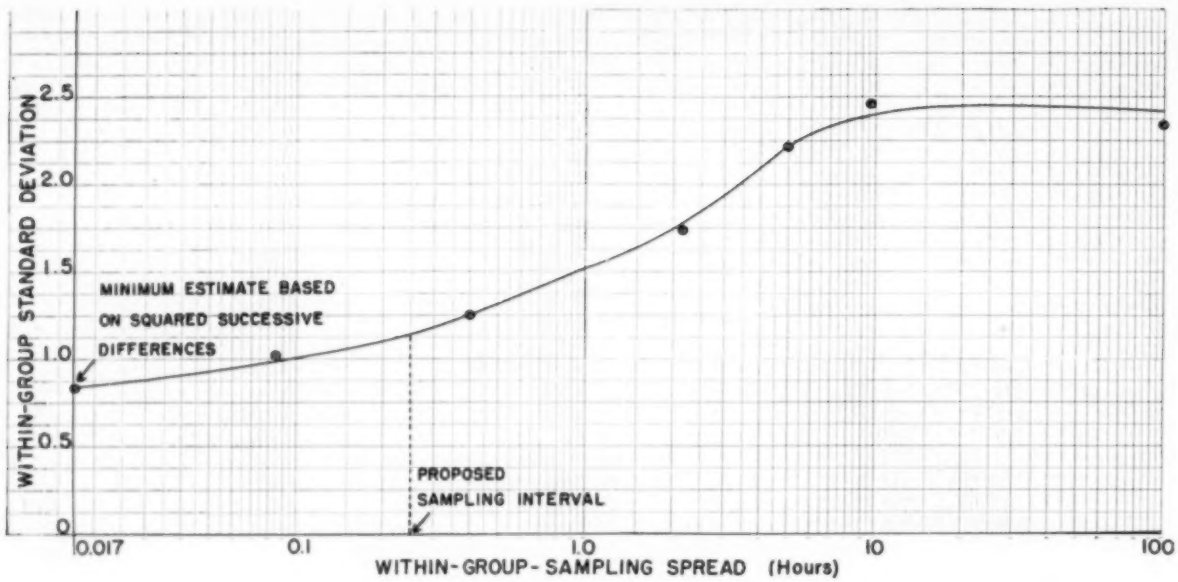

Figure 1.—**Relationship Between Within-group Standard Deviation and the Within-group Sampling Spread**

CONTROL OF CHEMICAL COMPOSITION

Batch Processes

Where it is desired to control some element of chemical composition such as moisture content or salt content, perhaps the typical procedure is to check *every* batch before processing, standardizing where possible those found out of line. Both sampling and analysis errors are present so that statistical procedures are needed to arrive at a rational rule to decide when the analytical results are sufficiently out of line to justify the conclusion that the batch requires adjustment. In order to do this, it is first necessary to determine the size of these sampling and analytical errors. Traditionally, the sampling error is disregarded entirely and the analytical error is assumed to be given by the mean difference between duplicates run through together by the analyst.

Actually, the adequate determination of analytical and sampling errors can best be made by a series of experimental sampling and analytical runs, designed so that the results are amenable to the analysis of variance. The reader is referred to standard textbooks[2] for an account of this method and to a recent article in *Industrial Quality Control*[3] for an application similar to the present one.

We took two random samples from each of a number of batches and had a number of analysts located in different laboratories carry out four analyses on each sample. The analyses were carried out as two pairs of simultaneous duplicates, one pair carried out on one day and one on another. We partialled out the components of variance and got the following results

1. Error variance (within simultaneous duplicates) 0.06%
2. Between - periods - within-persons 0.20%
3. Between-persons (and locations) 0.22%
4. Between - samples - within-batches 0.08%

Total 0.56%

The total of the four components is a realistic estimate of the overall variance of the sampling and analytical procedure, and the corresponding standard deviation can be used as a basis for the calculation of quality control limits which must be exceeded before action is taken in standardizing a batch of material ready for processing. As can be seen, the overall error is far larger than the simultaneous duplicate variance alone, a fact which has been noted by Wernimont[4] and others. It has even been suggested that a simultaneous or contiguous duplicate be referred to as a "duplicity."

By reference to production records we obtained the analytical figures for 49 successive batches of the material and calculated their variance. All were analyzed by the same analyst so that the overall error on the basis of the items above should be 1 + 2 + 4 = 0.34 percent. The observed variance between batches was 0.37 percent which is not significantly greater than the overall analytical error of 0.34 percent, so that the real batch-to-batch variation is certainly negligible compared to the precision of the overall analytical procedure. In other words, the error of the controlling procedure is far greater than the batch-to-batch error it is supposed to be controlling. The upshot of this is that standardizing adjustments formerly being made on the results of analyses were increasing rather than decreasing the batch-to-batch variation.

It is evident that once *realistic* control limits for action have been established as described above, most of the normal batch-to-batch variations are going to pass undetected and uncorrected. However, such an analytical check does serve as a kind of coarse screen to sift out definite production mistakes; e.g., where an

ingredient got omitted or a solution got routed into the wrong vat, etc.

Also such a control procedure exerts a healthy psychological influence on production personnel.

It is particularly important to have a realistic estimate of overall analytical error when the chief object of the analysis is to ensure that composition meets minimum legal requirements. What one wants to know is not the average difference between two determinations both carried out at the same time and place, but rather the average difference between two determinations, one of which is done by you at one laboratory and the other by a government official at another.

Investigations into analytical error using the analysis of variance technique as described above may also give valuable insight into the method itself and also the analysts. The reader is referred to reference[5] at the end of this paper for an excellent example of this.

Owing to the necessity of getting results as quickly as possible, less precise short-cut analytical methods are often to be preferred to standard methods; also bringing the control laboratory within the plant[2] and streamlining communications so that plant operators take action with a minimum of delay greatly increases the effectiveness of quality control. Too often, in the food industry, so-called quality control consists of a department which finds in *retrospect* why something went wrong, or even worse, merely accumulates sheets and sheets of data which no one ever bothers to look at.

It is not always realized that routine analysts are subject to inspection fatigue just as are QC inspectors conducting, say, visual examinations of components for assembly in the engineering industry. This is particularly the case where samples with defective composition are very rare. The analyst becomes so accustomed to finding a certain percentage of a given ingredient in a sample that he may misread his instruments or make a computation error, so that, unconsciously, the result is made to agree with what is normally found. This situation is not easily remedied.

Continuous Processing

The trend in the food industry now seems to be toward continuous production techniques and away from batch processes. The tendency is for such processes to be smoother, more precise, and easier to control, especially where the batches of the corresponding batch process are small and numerous. Also, continuous production techniques may be amenable to control by servo-mechanisms. A start has been made in the food industry in the application of these elegant techniques to the control of concentration, pH, temperature and other factors.[6] Such techniques imply, of course, a continuous automatic sampling of the product in process.

PHYSICAL PROPERTIES

When we come to consider the measurement of the physical properties of foods, we encounter some rather special difficulties. Many foods have important physical properties lying vaguely in the rheological field, which up until recently have had to be measured subjectively; for example, the grading of cheese for "body." Recent efforts have been to replace such subjective judgments by objective tests of various kinds, so that reliable estimates may be made by semiskilled technicians.

Baron and Harper[1] have made extensive correlation studies on cheese, using a battery of six instruments (such as penetrometers, hardness testers, breakers, etc.) and a series of subjective ratings by experts for the qualities of "springiness," "firmness," "crumbliness" and overall quality. They subjected the matrix of intercorrelations obtained to a mathematical procedure known as "multiple factor analysis," developed by some mathematically minded psychologists.[3] The object of this was to attempt to discover what basic variables lie behind all these tests and ratings and so gain insight into what is actually being measured. This in turn would suggest what further types of tests might be devised which would be an improvement on those already tried. Baron and Harper found that only four fundamental factors were required to account for all the observed intercorrelations. Multiple regression equations can, of course, be set up so that readings from different instruments can be entered into the equation which then gives the best possible estimate of the rating with respect to the quality in question without the use of experienced graders. It is perfectly possible for such a procedure to give a *more* reliable estimate of true grade than the judgment of a single skilled grader.

Kramer[4] has published a series of interesting papers on the objective testing of the physical and organoleptic quality of vegetables.

Such studies could profitably be made of many food products where physical properties are of cardinal importance, such as starch and agar gels, oil emulsions (e.g., salad dressing products) enrobing chocolate, etc.; *relevant*, rapid and precise objective methods of estimating physical characteristics would greatly assist quality control.

ORGANOLEPTIC PROPERTIES

Organoleptic quality control of food products is carried out in two chief ways

A. By individual experts, as, for example, in the case of the wine and tea industries

B. By taste-test panels

The judgment of an expert may be more reliable than the average of the judgments of a group of panel members, but where there are no established experts, a taste-test panel procedure, properly conducted, is probably the next best thing. The one great advantage of taste-test panel data is that estimates of the standard error can be calculated in each case, which cannot be done for isolated judgments by experts. There is now an extensive literature dealing with the proper design of taste-test panel procedures and the statistical analysis of the data obtained.

With many food products, the chief cause of organoleptic variation is the progressive change in the quality of raw materials from the beginning to the end of the growing season; e.g., frozen vegetables, ketchup, orange juice, etc. In such cases, controlling the quality of the raw materials may be the most effective single way of controlling the quality of the final product. Such control is typically done by graders, but here again there is scope for objective methods which may do the job as well or better.[6]

The most obvious feature of organoleptic judgments is their low reliability, so that reliable estimates may require large numbers of individual judgments. But what is sauce for the goose is sauce for the gander; the fact is sometimes lost

sight of, that the consuming public is probably not more, and may be a lot less discriminating in their organoleptic judgments. Furthermore, the conditions under which the product is normally consumed may be less critical for the detection of flavor nuances than those under which it is taste-tested by the producer. Perhaps ultimately the control limits of our control charts for organoleptic quality should be based upon measured estimates of the differences in quality which can just be be detected by the average consumer.

In conclusion, there is no doubt that the food industry does have its special problems when it comes to the application of statistical methods and statistical quality control; but so has every other industry. To the QC practitioner and the industry such problems should be regarded as a challenge rather than an obstacle.

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Estimating the Standard Deviation Of A Normal Population

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INTRODUCTION

Practical problems frequently involve the estimation of a common standard deviation σ from several groups of observations. Although the existing literature on this problem is extensive (see Davies and Pearson [1]), the major portion of it is not readily available to those concerned with industrial applications. For this reason a brief summary of the important results seems warranted.

The guiding principle for selecting a best estimator of σ in sampling from a normal population has been to choose from the class of estimators whose long-run means are σ, that one which has the smallest variance. The relative worth of any other member of this class has then been determined by calculating its efficiency, defined as the ratio

$$E = \frac{\text{Variance of best estimator}}{\text{Variance of estimator in question}}.$$

Although this concept has proved extremely useful in establishing the supremacy of a root mean square statistic for estimating σ from a single group of observations, it has all too frequently been misinterpreted when several groups are available.

In what follows we shall partition the loss of efficiency of several commonly used statistics into two major portions—one attributable to the method of grouping the data, and the other attributable to the type of statistic calculated. As a result of this partitioning we shall see that, in many cases, low efficiency is almost wholly due to the method of grouping.

SAMPLES FROM THE SAME POPULATION

Let $x_{11}, \ldots, x_{1n}; x_{21}, \ldots, x_{2n}; \ldots; x_{k1}, \ldots, x_{kn}$ represent k random samples each comprised of n independent observations from the same normal population with mean μ and standard deviation σ.

When the value of the common mean μ is unknown—the usual case—the best (minimum variance, unbiased) estimator of σ is the root mean square statistic

$$S_1 = C_1 \sqrt{\frac{1}{kn-1} \sum_{i,j} (x_{ij} - \bar{x})^2},$$

where $\bar{x}$ is the mean of all kn observations and C_1 (which depends on kn–1) is a constant that adjusts the estimate for bias.* The important feature of S_1 is that it fully utilizes the fact that each subgroup of n arises from the *same* population, by treating the observations as a *single* sample of size kn.

If we now decide to group the data into k samples of size n and if in estimating σ we ignore the dispersion of

*If the value of μ were known, then in the formula for S, one would put μ in place of $\bar{x}$ and use kn as divisor instead of kn-1, thereby utilizing the additional information on σ supplied by kn $(\bar{x}-\mu)^2$, which has a long-run average or "expected" value of σ^2.

the averages of the groups, then we will get a less efficient estimator (larger variance) no matter what type of statistic we calculate from each sample. The best that we can do under these circumstances is to calculate a mean square estimator s_i^2 from each subgroup, average these, and extract the square root, to obtain

$$S_2 = C_2 \sqrt{\frac{1}{k} \sum_{i=1}^{k} \left[\frac{1}{n-1} \sum_{j=1}^{n} (x_{ij} - \bar{x}_i)^2 \right]} = C_2 \sqrt{\frac{1}{k} \sum_{i=1}^{k} s_i^2}$$

TABLE I

Efficiency E_2 of the Statistic S_2

k	n				
	2	3	4	5	∞
2	.65	.79	.85	.89	1.00
3	.59	.74	.81	.86	1.00
4	.56	.72	.80	.84	1.00
5	.55	.71	.79	.83	1.00
∞	.50	.67	.75	.80	1.00

Efficiency E_3 of the Statistic S_3

k	n				
	2	3	4	5	∞
2	.62	.76	.83	.86	1.00
3	.55	.71	.78	.83	1.00
4	.52	.68	.76	.81	1.00
5	.50	.67	.75	.80	1.00
∞	.44	.61	.70	.76	1.00

Efficiency E_4 of the Statistic S_4*

k	n					
	2	3	4	5	50	∞
2	.62	.76	.81	.83	.48	0
3	.55	.70	.76	.79	.48	0
4	.52	.68	.74	.77	.48	0
5	.50	.66	.73	.76	.48	0
50	.44	.61	.69	.73	.48	0
∞	.44	.60	.69	.72	.48	0

*For k = 2 and 3 the maximum efficiency ocurs at n = 6. For k = 4 or more it occurs at n = 8.

where $\bar{x}_i$ is the mean of the n observations in the i-th sample, and C_2 (which depends on k and n–1) is a constant that adjusts the estimator for bias. The efficiency of S_2, defined as

$$E_2 = \frac{\text{Variance of } S_1}{\text{Variance of } S_2}$$

is tabulated in Table I. Since we have used the most efficient statistic possible for each sample of n, the increase in the variance of S_2 over that of S_1 is wholly attributable to grouping.

This fact is clearly displayed by considering the number of degrees of freedom in each case. The estimator S_1 utilizes all the degrees of freedom available, namely (kn–1); while S_2, ignoring the (k–1) d.f. between samples of n, uses only the remaining k(n–1). In fact, the efficiency E_2 is approximately equal to the ratio

$$\frac{k(n-1)}{kn-1}$$

(exactly equal in the limiting cases as n or k becomes large).

The next best choice is to calculate a *root* mean square estimator s_i from each sample and average these to get

$$S_3 = C_3 \frac{1}{k} \sum_{i=1}^{k} \sqrt{\frac{1}{n-1} \sum_{j=1}^{n} (x_{ij} - \bar{x}_i)^2} = C_3 \frac{1}{k} \sum_{i=1}^{k} s_i$$

where C_3 (which depends on n) is again the bias-removing factor. The efficiency of S_3 (Table I) is lower than that of S_2 because the square root is extracted before averaging. However, this additional loss is quite small in comparison with that due to grouping.

TABLE II—Partitioning the Total Loss in Efficiency

The upper entry represents the percent of the total loss in efficiency that is due to grouping, namely $100(1-E_2)/(1-E_i)$ for i = 3, 4; and the lower entry, the percent of the total loss that is due to the use of an inefficient statistic for each subgroup, namely $100(E_2-E_i)/(1-E_i)$ for i = 3, 4.

The Estimator S_2

100 percent of the loss is due to grouping

The Estimator S_3

k	n			
	2	3	4	5
2	93 7	88 12	86 14	84 16
3	92 8	87 13	86 14	84 16
4	91 9	87 13	85 15	84 16
5	91 9	87 13	85 15	83 17

The Estimator S_4

k	n			
	2	3	4	5
2	93 7	85 15	79 23	66 34
3	92 8	85 15	79 21	69 31
4	91 9	85 15	79 21	71 29
5	91 9	85 15	79 21	71 29

Finally, let us consider the "quick" estimator obtained by calculating a range for each sample of n and averaging these. Denoting it by S_4, we have

$$S_4 = C_4 \frac{1}{k} \sum_{i=1}^{k} R_i$$

where R_i is the range of the i-th subgroup, and C_4 (which depends on k and n) is still the bias-removing factor. Although the efficiency of S_4 (see Table I) is the lowest of all the statistics considered, the additional loss over that of S_2 is negligible when n is small.

To obtain a sharp quantitative picture let us express the total loss of efficiency; i.e., $(1 - E)$, in each of the above estimators as

Total Loss = Loss Due to Grouping
+ Loss Due to Use of Inefficient Statistic.

The relative magnitudes of these terms are shown in Table II as percentages of the total loss. It is apparent that for the small subgroup sizes considered the major portion, by far, is that due to grouping.

SAMPLES FROM DIFFERENT POPULATIONS

In this case our set of data is not homogeneous, the subgroups $x_{i1},\ldots,x_{in}$ being random samples from normal populations with the *same* standard deviation σ but *different* means.

TABLE III

$$\text{Efficiency } E_i' = \frac{V(S_2)}{V(S_i)} \quad \text{for } i = 3, 4$$

Efficiency E_3' of the Statistic S_3

k	n				
	2	3	4	5	∞
2	.96	.96	.97	.98	1.00
3	.94	.95	.95	.97	1.00
4	.92	.94	.95	.96	1.00
5	.91	.94	.95	.96	1.00
∞	.88	.91	.94	.95	1.00

Efficiency E_4' of the Statistic S_4

k	n					
	2	3	4	5	50	∞
2	.95	.96*	.95	.93	.49	0
3	.93	.94*	.93	.92	.49	0
4	.92	.93*	.93	.92	.49	0
5	.91	.93	.93*	.92	.49	0
50	.88	.91	.91*	.91	.49	0
∞	.88	.91	.91*	.91	.49	0

*Maximum efficiency

The estimate S_1, although best in the first case, is now useless because of an unknown bias. Its mean in repeated sampling is no longer σ, but is inflated by the variability among the population means. The best statistic to use in this case is S_2 and the relative efficiency of any other estimate is properly obtained by comparing its variance with that of S_2 (see Table III).

CONCLUSIONS

The results are decidedly different in the two cases. In the first case, when all the data are drawn from the same population, the estimate S_1 is distinctly superior, while the gain in choosing S_2 over S_3 or S_3 over S_4 is practically nil. In the second case, when the populations are different, S_1 is out of the question, while the variances of the last three are approximately on a par.

In many practical situations we are confronted with the second case rather than the first. The kn observations are often broken into a number of subgroups differentiated because of certain assignable causes which may affect the mean value of the characteristic being measured but which are unlikely to affect the variability within a subgroup. For example, we frequently estimate the standard deviation of an industrial process by computing ranges of small samples accumulated over a long period of time and averaging these to get the estimate S_4. Since the process mean may change between the times these samples are drawn, the grouping is mandatory.

In cases like the above, the slight gain in efficiency that would result by using S_2 or S_3 instead of S_4 is offset by the simplicity of calculating an average range.

Acknowledgment

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Appendix

The efficiencies given in Table I for small values of n and k were obtained by computing the ratios

$$E_2 = \frac{V(S_1)}{V(S_2)}$$

$$E_3 = \frac{V(S_1)}{V(S_3)}$$

$$E_4 = \frac{V(S_1)}{V(S_4)}$$

where the $V(S_i)$ are the variances of the estimators concerned. $V(S_4)$ was obtained from tables given in reference (1), and the others by evaluating the well-known expressions

$$V(S_1) = \left[\frac{kn-1}{2} \frac{\Gamma^2\left(\frac{kn-1}{2}\right)}{\Gamma^2\left(\frac{kn}{2}\right)} - 1 \right] \sigma^2$$

$$V(S_2) = \left[\frac{k(n-1)}{2} \frac{\Gamma^2\left(\frac{kn-k}{2}\right)}{\Gamma^2\left(\frac{kn-k+1}{2}\right)} - 1 \right] \sigma^2$$

$$V(S_3) = \frac{1}{k} \left[\frac{n-1}{2} \frac{\Gamma^2\left(\frac{n-1}{2}\right)}{\Gamma^2\left(\frac{n}{2}\right)} - 1 \right] \sigma^2$$

For the limiting cases in which n or k becomes large we have

$$V(S_1) \to \frac{\sigma^2}{2(kn-1)}$$

$$V(S_2) \to \frac{\sigma^2}{2(kn-k)}$$

Hence

$$E_2 = \frac{V(S_1)}{V(S_2)} \to \frac{k(n-1)}{kn-1}$$

As $n \to \infty$, with k fixed, this expression approaches unity; while as $k \to \infty$, with n fixed, it approaches $(n-1)/n$.

As $k \to \infty$, with n fixed, the following expressions for E_3 can be easily verified

$$\text{for } n = 2,\ E_3 \to \frac{1}{2(\pi-2)}$$

$$\text{for } n = 3,\ E_3 \to \frac{\pi}{6(4-\pi)}$$

$$\text{for } n = 4,\ E_3 \to \frac{1}{3\pi-8}$$

$$\text{for } n = 5,\ E_3 \to \frac{9\pi}{10(32-9\pi)}$$

Quality Control in Receiving Inspection

E. F. GRAUMENZ

Carrier Corporation

INTRODUCTION

QUALITY Control at Carrier Corporation is a continuous process. It must begin at the design stage and continue through to the completion of the product—and even to installation and service of the product. It exists from the raw materials through subassemblies and completed assemblies that have their origin at our vendors' plants. We feel that quality control has been instrumental in obtaining and holding the respect and confidence of the general public, and has been a contributing factor in making Carrier Corporation a leader in air conditioning today.

Acceptable quality levels are not static. Changing market conditions and consumers' acceptance levels necessitate a constant adjustment of emphasis and improvement of control. New developments in testing equipment and methods obsolete some procedures soon after they are written. Hence, it is difficult to state definite programs for future use.

With the above qualifications in mind, this article is written to acquaint the reader with the many procedures and controls currently employed by the Quality Control Department operating within our Receiving Inspection Department.

Our purchased parts range from raw material, such as steel, lumber and paint, to subassemblies and complete assemblies such as motors and compressors; from simple fittings such as screws, nails, and washers, to completed semi-finished parts, such as crankshafts, control panels and seals. It is most important to know the quality of the parts and materials we purchase, since all the parts that go into the manufacture of a Carrier product must first pass through receiving inspection in one form or another. Thus, we attempt to control the quality of all purchased parts. To accomplish this one result requires the complete cooperation of each vendor with Carrier.

Originally Receiving Inspection operated on pretty much of a hit or miss basis, with some items receiving an exhaustive 100 percent inspection, while others were subjected to only a cursory examination of one or two samples taken from the most convenient spot in the container in which the part is received. Items were divided into two general classifications on the basis of past difficulties

1. troubles found on the assembly line
2. problems encountered in the field

The shortcomings of such a system are obvious. It was all hindsight and no foresight. In addition, the cost of 100 percent inspection done in most cases, was extremely high. So high in some instances as to exceed the cost of the trouble it was designed to prevent.

Inspection procedures, if they existed at all, were left to the discretion of the inspection foreman of Receiving Inspection in most cases. It was only when extreme problems developed at assembly or in the field that special consideration was given to inspection procedures or gaging methods. Here again it is obvious that such a system is characterized by hindsight rather than foresight. Also, at that time, the gaging that was provided Receiving Inspection was furnished through a separate

department; complications were bound to occur, and the full value of proper gaging could never be realized.

The first steps toward improvement were taken in the fall of 1944 when several employees were trained in the techniques of quality control and then brought into the Inspection Department. They were assigned primarily to the Receiving Inspection Department, with the purpose in mind of revamping, as far as practical, the operation of the department along the accepted lines for efficient operation. Unfortunately, these individuals were better statisticians than inspectors. Therefore, although a form of sampling was instituted and many inspection procedures written, we still experienced considerable difficulty due to lack of practical experience on the part of the QC engineers concerning the usage of parts and proper gaging techniques.

With a great deal of effort we were, however, able to educate our inspectors in the proper techniques of sampling, the meaning of the terms "random sampling," "single sampling," "double sampling" (Dodge-Romig), "sequential sampling" and the Army-Navy Ordnance tables. The importance of accurate records became apparent not only to each inspector, but through the supervisory level as well.

During the period from 1945 to 1949, progress was slow. This was the transition period from war work to civilian production. Changes in products, techniques and personnel had detrimental effects on the progress. However, by 1949 most of the uncertainties had cleared and we had established what we considered a sound QC organization with one well-qualified QC engineer being assigned to control the quality within our Receiving Inspection Department.

In order to understand more clearly the set-up explained here, we should first describe our material stock flow. Since receiving inspection is the prime origin within the plant, it plays a major role in our QC program. To be effective, it must be fitted carefully into a regular system of material flow. Figure 1 shows how this operates. Material coming from our supplier enters the receiving area where its entry into the plant is recorded on receiving slips for accounting and stock control purposes. The material then enters the receiving inspection area where it is checked against specifications and classified according to quality levels. If we find that the material meets our specifications, it is approved and moved into the production control stores area, where it is available for use by the Production Department. However, if we find that the material does not meet specifications, we route the material to the vendor rejection area, which is under the jurisdiction of Quality Control, for prompt return to the suppliers.

MATERIAL STOCK FLOW

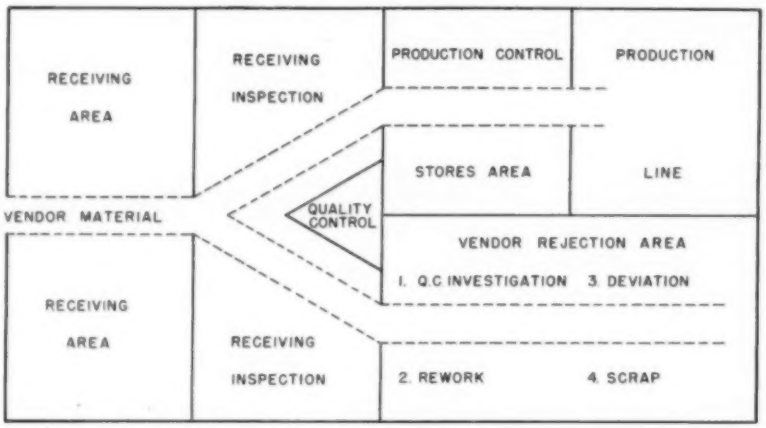


Figure 1—**Material Stock Flow**

Occasionally, because of a parts shortage, an off-standard shipment may be needed to keep the production line in operation. In such case before the material can be used, a Deviation must be issued and approved by Manufacturing, Sales and Engineering Divisions. The material can then be 100 percent sorted with the good parts accepted and the defective parts returned to the vendor, or else the parts may be reworked in our own plant. In any event, all unacceptable material must be carefully studied by the QC engineer before final disposition is made.

In obtaining efficiency in our Receiving Inspection Department, it is essential that all incoming material be routed according to Fig. 1, since only in this way can we assure our Production Department high quality material and thereby furnish quality merchandise to our public. If our flow system is not properly set up, material is allowed to go into manufacturing without being inspected and, even worse, rejected material seeps into our product. The results of such loose control appears almost immediately in lowered manufacturing efficiency and in a poor product quality.

In the receiving inspection area, the QC engineer plays an important role. In setting up his assignment, several important decisions had to be reached during his first weeks in the department. Among them were the following:

1. What type of sampling to employ in order to provide us with the best possible protection along with the least possible cost
2. How to evaluate properly the quality levels necessary on each part
3. How to provide the best possible inspection procedures with respect to sequence of operation, gaging, etc.
4. How to handle items not meeting specifications
5. How to handle vendor relations
6. How to collect the data properly and record them in appropriate form
7. How to report our results to management

CHOICE OF SAMPLING PLANS

With regard to Item 1, the determination of sampling plans to be

used, several basic policies were established.

Single sampling would be employed generally. This decision was reached since we felt that the level of our present inspectors could more easily grasp such a plan. Also, our past experience indicated that our primary problem was not to protect against border-line lots (those lots having a percent defective only slightly more than our acceptable quality level), but against lots with a high percent defective. In general, inspection would be charged back to the vendor. (It should be noted that such costs eventually are charged against the product in succeeding contracts. Herein, immediate effects on cost are being considered.)

The single-sampling plans to be employed would be taken from Dodge-Romig tables, and then modified slightly in order that they may be more suitable for our purposes. Figure 2 shows the table which is currently employed. You will notice

SAMPLING PLANS FOR ACCEPTANCE OF PURCHASED MATERIAL

QUALITY CONTROL SUB-DIVISION
RECEIVING INSPECTION DEPARTMENT

CARRIER CORPORATION
NOVEMBER 1, 1950

A.O.Q.L.	0%		1.0%		2.5%		5.0%		10%		-		2%			
Lot Size	Plan A		Plan B		Plan C		Plan D		Plan E		Plan F		Plan D.S.			
	N	C	N	C	N	C	N	C	N	C			N	C	N	C
1-50	30	0	25	0	10	0	5	0	5	0			15	0		
51-100	40	0	30	0	15	0	5	0	10	1			20	0	15	1
101-200	55	0	30	0	15	0	15	1	10	1			25	0	15	1
201-300	60	0	30	0	30	1	15	1	10	1			30	0	30	2
301-400	60	0	35	0	30	1	15	1	15	2			30	0	35	2
401-500	65	0	35	0	30	1	15	1	15	2			30	0	35	2
501-600	65	0	75	1	30	1	25	2	15	2			35	0	55	3
601-800	65	0	75	1	30	1	25	2	15	2			35	0	60	3
801-1000	70	0	80	1	30	1	25	2	15	2			35	0	60	3
1001-2000	155	1	80	1	55	2	25	2	20	3			35	0	60	3
2001-3000	160	1	80	1	55	2	40	3	20	3			40	0	85	4
3001-4000	160	1	135	2	55	2	40	3	25	4			40	0	90	4
4001-5000	165	1	135	2	75	3	40	3	25	4			40	0	90	4
5001-7000	265	2	135	2	75	3	40	3	25	4			45	0	135	4
7001-10,000	265	2	135	2	75	3	50	4	30	5			45	0	135	5
10,001-20,000	270	2	195	3	100	4	50	4	30	5			50	0	135	5
20,001-50,000	390	3	255	4	100	4	70	5	40	6			50	0	135	5
50,001-up	510	4	255	4	100	4	70	5	40	6			50	0	150	6

Notes: 1. Above plans are to be used in accordance with the approved Quality Control Inspection Procedure Cards. - Form - P-20.

2. N= Sample size, C= allowable defects

3. Plan D.S. is a double sampling plan to be used on special items. N= First sample and material is passed if C_1 or less defective are found. If more than C_1 defects but C_2 or less defects are found than the second sample N_2 is to be taken and the material rejected if the total defects found exceeds C_2.

Figure 2

even if double or sequential sampling were to be employed, we would seldom be forced to use a second sample since the current process averages are at levels at which a second sample is seldom required. In addition, the tendency for an inspector to give a particular lot of material a second chance because he might question his first lot inspection, would be minimized by employing only single sampling.

Although one table of double-sampling plans is provided, it seemed advisable to use the single-sampling plans because of their simplicity. We do not feel that the argument of reduced inspection by double sampling should be encouraged in our case since any detailed inspection necessary would be done by the vendor himself, or, if performed by Carrier, the costs for such that we have rounded off these quantities being inspected to the nearest five pieces in every instance, which only increases or decreases our sample size by two in any case. We have, in addition, eliminated the extremely small lot size plans, since our receivals very seldom come in lot sizes under 300 pieces.

Therefore Carrier has adopted a "rule of reason" in applying the A.O.Q.L. principle which is an average past performance level of one-half of the percent defective A.O.Q.L. This has been done arbitrarily with the thought in mind that the past performance with respect to quality levels would be considered when the plan was chosen, rather than after the plan had been adopted. Admittedly, some errors may exist with respect to our A.O.Q.L. However, considering the overall program which has been set up to select a sampling plan, we do not feel these errors to be significant.

Some special items, where past experience has pointed to advantageous use of a double-sampling plan, or where the cost of rejecting material too rapidly is prohibitive, will still be handled by double sampling, and, in certain isolated cases, on a more or less trial basis by a sequential-sampling plan. Application on certain contracts will also call for the use of Army Ordnance tables.

The use of random-number tables to assure randomization of samples was considered but discarded for the following reasons. In general, the type of defect we are looking for is not apparent at the time selection is made, hence personal bias on the part of the inspector is not possible. In addition, the use of random-number tables would again require more instruction and supervision of inspectors. Also, since many shipments are received in individual crates or cartons, the possibility of whole groups being untouched is considerable when random-number tables are used. We use, therefore, what might be considered a cross between random and systematic sampling in that samples must be taken from each container in a given shipment, and within this container, the samples must be drawn from dispersed locations. It is our feeling that this gives us as representative a sample as we would have if random-number selection of samples were employed.

Another important decision reached with regard to sampling plans was to work to an A.O.Q.L. rather than a lot tolerance percent defective. This decision was based on the fact that Carrier's method of storing material makes the identity of individual lots in stores impossible. Therefore, to control quality by lots would be excessively expensive from an inspection cost standpoint.

After a lot of material is inspected and fails to meet the applied sampling plan, the material is immediately vendor rejected. Paper work is issued in preparation for returning the material to the vendor for his reinspection. The QC Department, at times, may be informed by management that the material is urgently needed to prevent a shutdown of production and in such cases it is necessary for us to approach this rejected material in the following manner:

1. Material is subjected to investigation by the Material Board of Review, and if it is agreed on, the material may be accepted on an approved deviation
2. Material is 100 percent inspected by the Receiving Inspection Department and charges for same charged back to the vendor at the rate of $3.50 per hour
3. Material is reworked at Carrier as per the instructions of the Material Board of Review and the charge placed against the vendor at the rate of $3.50 per hour
4. The cost of scrapping defective purchased material in non-acceptable lots is handled by returning this defective material to the vendor or, upon his approval, by scrapping it at Carrier at his expense. It should be added here that for acceptable lots the few defective pieces found in sampling the lot, are scrapped at Carrier's expense.

EVALUATION OF QUALITY LEVELS

With regard to Item 2 of our original decisions, the proper evaluation of quality levels on each part, a great deal of effort and thought was given to the proper evaluation, as it was difficult to find any standardized methods to determine those A.O.Q.L.'s which we felt were satisfactory for our use. Hence, we established our own. The discussion in this section is a brief outline of the method of evaluation.

Six single-sampling plans have been chosen arbitrarily as follows:

Plan	*A.O.Q.L*
A	.5%
B	1.0%
C	2.5%
D	5.0%
E	10.0%
F	Spot Check

These six plans cover the complete range of quality levels we seek to maintain in any given instance.

Since it is obvious that the various dimensions vary in importance as well as the parts themselves, each dimension on each part is rated individually as to the sampling plan to be used with consideration given to the following points.

1. Specification Tolerances (per blueprint)

Tolerance Range Spread	*Use Plan*
.0001"—.0010"	A
.0011"—.0049"	B
.0050"—.0100"	C
.0101"—1/64"	D
1/32"—1/16"	E
Unspecified	F

(Inspection points not specified as a tolerance dimension are rated on the preceding bases by judgment and investigation.)

2. Past Performance

Past Percent Defective	*Use Plan*
Near anticipated A.O.Q.L	A
Worse than anticipated A.O.Q.L	B
Better than anticipated A.O.Q.L	C
Rejects constantly high	D
Material consistently top quality	E
Not used	F

3. Cost of Defect

Discovery of Defect	*Use Plan*
In the field	A
After final assembly	B
After subassembly	C
During assembly process	D
Upon selection of part to be used	E
In control stores	F

4. Inherent Variability of Dimension

Variability	*Use Plan*
Exceeds tolerance spread	A
Equals tol. spd. (75%—100%)	B
Less than tol. spd. (50%—75%)	C
Slight (25%—50%)	D
Very slight (1%—25%)	E
Not used	F

After the preceding four points have been considered, we must temper the results by the following two factors:

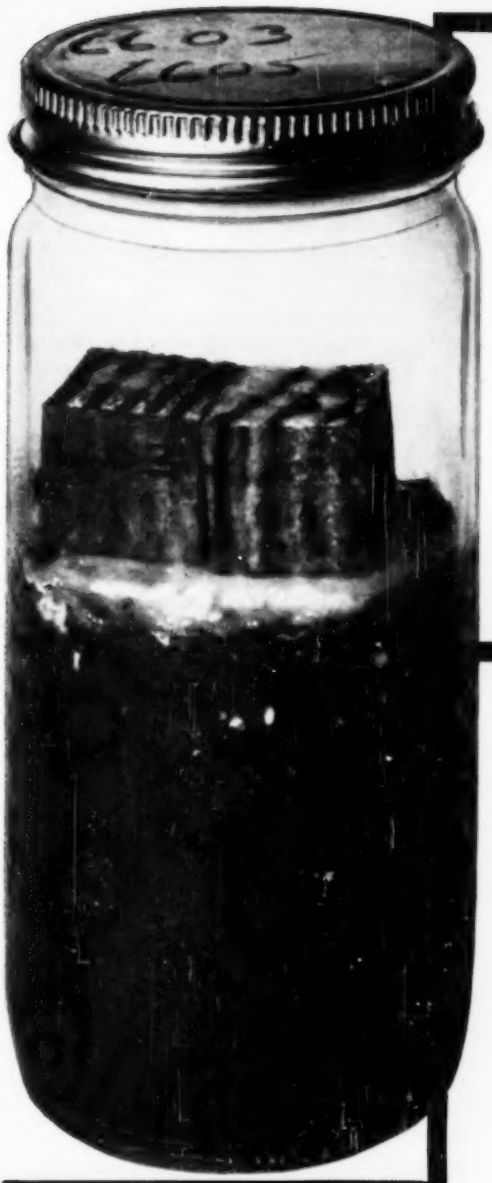
1. Cost of inspection. It may be necessary to reduce the plan slightly if the cost of inspection is extremely high, and, on the same basis, we can tighten the plan a slight degree if the cost of inspection is extremely low.
2. Accuracy of inspection. If there should be some question as to the continuous accuracy, the plan of inspection can be adjusted upwards slightly.

The method used for determining a plan in accordance with the above, then, is as follows: each of the four dimensions involved is determined and averaged out to secure a tentative plan which is then modified as necessary by cost and accuracy of inspection. Further, after each dimension has been rated, they are listed in order of importance and further modified so that no more than three or four plans are employed on a given part. This, then, is the final sampling plan that is put into use. All parts and plans are subjected to periodic review so that any changes in past performance, tolerances due to drawing changes, etc., can be incorporated into our plan. Also, any engineering changes effected by Development, call for a review of the sampling plan.

DEVELOPMENT OF INSPECTION PROCEDURES

With regard to Item 3, the preparation of inspection procedures, the following routine is being followed. First, it is the responsibility of the QC engineer out of Receiving Inspection, to investigate each part thoroughly as to usage, past history, etc. He must determine what gaging is available and secure additional equipment if necessary. He then prepares a Quality Control Inspection Procedure card (Fig. 3). This procedure card lists the inspection points to be covered, the inspection instruments to be employed, and the sampling plan to be followed. Second, the work of the QC engineer is reviewed by a standing committee made up of the chief inspector, the foreman of Receiving Inspection, the foreman of inspection in the department where the part is to be used, and the QC engineer. The committee chairman, the chief inspector, is privileged to call in any other special individuals as may be deemed necessary. Third, if the procedure is approved by this committee, it becomes the working guide for inspection. However it is always subject to periodic review and improvement.

The balance of the inspection routine is relatively simple. The inspector works from the blueprint or specification sheet using the inspec-



THIS BOTTLE TURNS SEVEN YEARS INTO SEVEN MONTHS

Test blocks of pole wood are fed to destructive fungi in bottles like this at Bell Laboratories. Wood rests on soil which controls moisture conditions and promotes fungus growth. Test speeds search for better preservatives.

This year the Bell System is putting 800,000 new telephone poles into service. How effectively are they preserved against fungus attack and decay?

Once the only way to check a preservative was to plant treated wood specimens outdoors, then wait and see—for seven years at least. Now, with a new test devised in Bell Telephone Laboratories most of the answer can be obtained in seven months.

Cubes of wood are treated with preservatives, then enclosed in bottles with fungus of the most destructive kind, under temperature and humidity conditions that accelerate fungus activity. Success—or failure—of fungus attack on cubes soon reveals the best ways to preserve poles.

The new test has helped show how poles can be economically preserved for many years. It is another example of how Bell Telephone Laboratories works to keep down the cost of your telephone service.

A boring is taken from a pole section to see how far preservative has penetrated. For poles to last, it must penetrate deeply and be retained for a long time.

BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in scientific and technical fields

QUALITY CONTROL INSPECTION PROCEDURE

part no. SF40-1084 — rev. J — date 10/25/49

part name CRANKSHAFT

no.	inspection point	inspection instrument	plan
1	Surface finish, chamfers, free from burrs. 2.061/2.060 surface ground square and smooth.	Visual and Square	B
2	1.6260/1.6233 Dia.	Snap Gage T6640	B
3	2.061/2.060 Dia. Drive End	Snap Gage T6641	B
4	1.503/1.500 Dia. Drive End	Snap Gage T6636	B
5	#21 Woodruff Keyway	#21 Woodruff Key	B
6	Alignment, squareness bearing journals	T12156	B
7	.9985/1.0005 "Im.	Surface Plate "V" Blocks	B
8	.0004 Out of round, shaft and journals	" " "	B
9	3" Taper Dia.	Taper Ring T130598	C
10	6.312/6.117 Dia.	Snap Gage T666	C
11	1.501/1.504 Dia.	T11847	C
12	.247/.255 "lot Location	T121582	C
13	1/4" Pipe Tap	Thread Gage	C
14	1/8" - 24 NPS Thread	Thread Gage	C
15	7/16" and 1/8" Oil holes drilled through.	Wires	C
16	2.831/2.821 Counter Balance Dia.	Depth Mics	C
17	2.879/2.869 Counter Balance Dia.	Depth Mics.	C
18	2-11/16" (2) Dias.	Depth Mics	C
19	2-25/32" dia.	Depth Mics	C
20	16-15/32" Overall Length	Veniers	C
21	1-11/32", 1-7/16" Location and 1/4" width of grooves	Scale	C
22	1/8" ∅ 1/16 - 0 Depth of keyway	Scale	C
23	Rockwell "C" 33-37		

Figure 3

tion procedure as a guide, and records all results as well as sample sizes, identifying purchase order numbers, part numbers, drawing numbers, etc., on the Quality Control Work Sheet. This work sheet then becomes the permanent record for our files.

The amount of care necessary in the preparation of the Quality Control Inspection Procedure card cannot be over emphasized inasmuch as this card becomes more important than the blueprint in actual practice. The QC engineer responsible for the preparation of these procedures must be completely familiar with the part as well as with approved QC techniques and standard gaging practices.

PROCEDURES FOR NON-CONFORMING ITEMS

With regard to Item 4, how to handle items not meeting specifications, this problem is handled in different ways in different companies. At Carrier the following procedure is used. Sub-standard or substitute materials are rejected and turned over to the vendor rejection investigator. It is his responsibility to look into all aspects of the particular problem presented. He will check with our Development Department to determine if the part may be used on deviation. He checks with Purchasing and Material Control to determine if any scheduling problems will be presented by the return of the material. He further checks with Production and Factory Engineering to determine if reworking is feasible and economically possible.

After having made the foregoing contacts as mentioned, this information is submitted by the QC engineer to the Material Board of Review, whose decision in the matter is final.

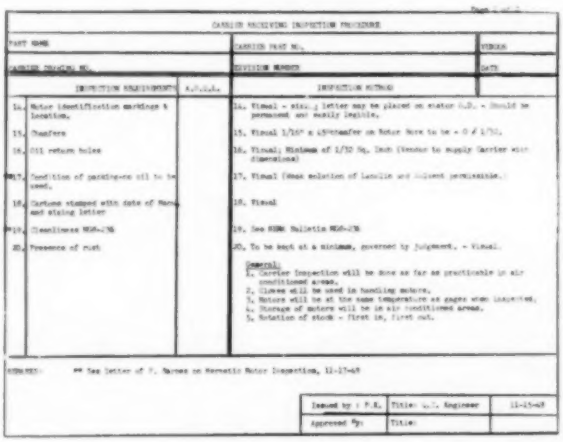
VENDOR RELATIONS

With regard to Item 5, how to handle vendor relations, we are currently embarking on a comprehensive program of vendor contact which we hope will eventually serve to give Carrier better vendor relationship.

The importance of vendor relations in the manufacturing cycle is best emphasized by pointing out that a considerable percentage of the costs of our products, in many cases, is made up of materials or parts processed outside of our own plants. Certain vendors actually quote on a process which includes a factor based upon past rejection records. In other words, if they find we regularly reject 15 to 20 percent of their parts, they add to the price to allow for this rejection rate, and we have been paying the bill.

Also, in connection with this vendor relation program, we have already started to supply our sampling plans and test specifications in the purchasing specifications, which will completely inform the vendor as to the exact basis on which we will accept or reject the materials specified and later we intend to rate our vendors in classifications known as "A," "B," "C," and "D," with the "A" classification indicating a highly satisfactory vendor and "D" indicating that the vendor is not acceptable and that Purchasing should be alerted to seek a new source. Too often in the past we have found ourselves in disagreements with our vendors concerning test methods and quality levels. If we can iron out our difficulties before full scale production has started, we can certainly eliminate disagreements, protect our quality levels on our finished products and save both ourselves and our vendors money. After all, we pay in some measure, either directly or indirectly, for our vendors' mistakes.

Figure 4 is a typical form which has been prepared and used for this purpose. It lists all important specifications with the acceptable quality levels that apply. It also shows, as far as practicable, exactly how we intend to measure compliance with the specification. We make clear to the vendor that if his material does not meet our quality level, it will be



CARRIER RECEIVING INSPECTION PROCEDURE

PART NAME — CARRIER PART NO. — VENDOR

CARRIER DRAWING NO. — DIVISION MARKET — DATE

	INSPECTION REQUIREMENTS	A.Q.L.	INSPECTION METHOD
14.	Motor identification markings & location.		14. Visual - stick; letter may be placed on stator O.D. - Should be permanent and easily legible.
15.	Transfers		15. Visual 1/16" ± 1/64"transfer on Rotor Bore to be - 0 / 1/32.
16.	Oil return holes		16. Visual; Minimum of 1/32 Sq. Inch (Vendor to supply Carrier with dimensions)
17.	Condition of packing-no oil to be used.		17. Visual (Weak solution of Lanolin and solvent permissible.)
18.	Cartons stamped with date of Manu. and stating letter		18. Visual
19.	Cleanliness MSH-276		19. See MSHC Bulletin MSH-276
20.	Presence of rust		20. To be kept at a minimum, governed by judgment. - Visual.

CONTROL:
1. Carrier Inspection will be done as far as practicable in air conditioned areas.
2. Gloves will be used in handling motors.
3. Motors will be at the same temperature as gages when inspected.
4. Storage of motors will be in air conditioned areas.
5. Rotation of stock - first in, first out.

REMARKS: ** See Letter of T. Haines on Hermetic Motor Inspection, 11-17-49

Issued by: P.E.	Title: Q.C. Engineer	11-15-49
Approved By:	Title:	

Figure 4

BRYANT INTERNAL THREAD GAGE

Revolutionary!

MODEL P-11

no other gage can tell so much— so fast—about internal threads

The P-11 Internal Thread Gage gives one accumulated reading of P. D., form and lead. Variation of these elements from basic size is shown on the dial indicator which reads in .0005". Interchangeable pairs of segments inspect all classes of internal threads from 5/16" to 5" dia. The segments work on the principle of an expanding master plug. This 14 oz. portable gage is designed for use in the shop or at the inspection bench. Descriptive literature on this gage and other Bryant gages is available on request. Send coupon today.

Bench type gages for external or internal threads are available, with or without squareness-of-face attachment.

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returned to him, or, if necessary to maintain production, will be sorted at his expense.

We have been able to convince vendors to make their own sampling tests to insure that the submitted product conforms to specifications, and to supply us, with each lot of material, the results of his tests. Such records bring about reduced rejection losses and give the vendor an opportunity to improve his process for our mutual benefit. Therefore, the vendor himself usually has lower costs and fewer uncertainties.

Lastly, combined meetings with the vendors are most beneficial to us, for at such meetings we can jointly discuss our many problems. When our QC Department arranges for such meetings, we always have available a representative from Development, such as the development project engineer, and also a representative from the Purchasing Department. Generally such meetings are held at the Carrier plant. However, there are occasions when we at Carrier will arrange for such meetings at the vendors' plants, particularly if we consider it advisable to study their process of manufacture.

The opportunities in this program are, in our judgment, tremendous. To realize them, our QC Department must make certain that the quality standard is crystal clear both to the supplier and ourselves, as well as to all interested members in the vendors' organizations.

PROBLEMS OF DATA

With regard to Item 6, how to collect data properly and record them on appropriate forms, our method of such collection of data has been generally described during the various phases discussed. It may be well to indicate the method of distribution of all the necessary paper work. This is shown in the flow chart of Fig. 5.

You will note from the flow chart the various forms that are handled by our Quality Control and Receiving Inspection Departments. They are the receiving report, purchase order, inspection procedure card (Fig. 3), quality control work sheet, blueprint, code sheet, vendor rejection, deviation and expense order. Each of these forms plays an important role in collecting the necessary data, and the flow chart indicates through which departments these various forms must pass in order to secure the permanent data.

It is most important that the data reported on each of these forms be accurate and all facts presented clearly because periodically this data is reviewed to determine whether a change in the sampling plan should be considered. You will note on the flow chart that all the reports on which important data is collected will be filled as a permanent record by the QC clerk. With reference to the vendor rejection, deviation and expense order, although we do not

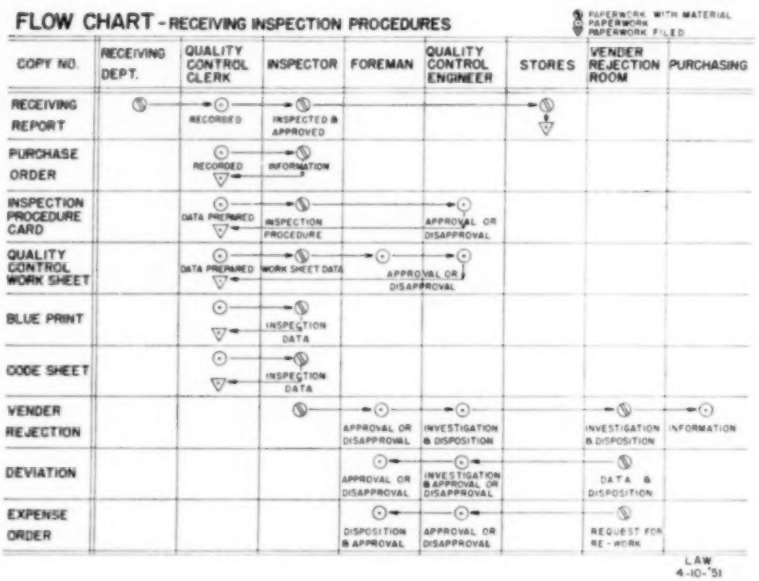

Figure 5

show a disbursement of all copies of the paper work, one copy of each of these three forms is also filed as a permanent record by the QC clerk.

All data collected is first reviewed by the foreman of Receiving Inspection and then turned over to the QC engineer in Receiving Inspection for final analysis. Reports of accepted material are filed, and reports on rejected material investigated.

Photostatic copies of the sampling plans shown in Fig. 2 are reproduced and furnished each receiving inspector as references. It might also be well to note in passing that each receiving inspector is briefed on the fundamentals of quality control, and from time to time all receiving inspectors are called together and informed of the latest developments in quality control which might pertain to their particular work.

REPORTS TO MANAGEMENT

With regard to Item 7, how to report our results to management, a balanced control must always include some degree of direct contact between the upper management, the inspection foreman, and the QC engineer. Each plays an equal part in supplying the information. This information can be related either by direct contact or in the form of reports. However, direct contact affords the opportunity to transmit, at first hand, firm policies on quality matters to those who, in the last analysis, must carry out the policies. First hand dealings, even if infrequent, leave lasting impressions. Weekly, monthly and yearly reports are submitted to top management such as the Production, Purchasing and Engineering Departments. These reports vary in nature from complaint reports, vendor analysis reports, sample inspection reports, investigations, and the weekly, month-

ly and yearly activity reports. Most of these reports have been referred to earlier in this paper and therefore will not be discussed here except to state that each of these reports is carefully prepared, promptly issued and then thoroughly analyzed by top management. Cost figures as to the savings realized are also carefully prepared and forwarded to top management for review, as management is always interested in cost savings which can be realized whereby the quality will not suffer.

This basically is the program we have set up in our Receiving Inspection Department and which has now been in operation for several years now. Again, it may require changes and corrections as we continue, but two general statements can be made of the department to date. First, as

Figure 6—**Cost of Receiving Inspection per 1,000 Productive Man-Hours**

shown in Fig. 6, the total cost of receiving inspection per 1,000 productive man-hours throughout the plant dropped from $40.00 during 1950 to $26.16 in 1951. A savings of over 30%, or, based on a $60,000 budget, a savings in excess of $20,000 was realized. We have just established that in 1952 we were able to realize a further saving, as the cost of operating receiving inspection was reduced to $15.60 per 1,000 productive man-hours. Secondly, the instances of assembly and field problems due to defective purchased parts were reduced at least 50% in the past two years, which represents many thousands of dollars saved in factory rework and field expenses. It likewise eliminated needless factory shut-downs due to lack of good parts on the assembly lines.

Some Remarks Concerning the Lot Plot Plan

C. C. CRAIG

University of Michigan

THE appearance in this journal of a set of papers[1] on the lot plot plan, all very much of the same tone, increases my conviction that at least one somewhat more critical discussion of this plan should be in print. It is a fact that a number of people concerned with the soundness of statistical plans proposed for use in industry have had serious reservations concerning the lot plot plan from the first. I believe it is unfortunate that these doubts, and the reasons for them, have not been forcefully set down before now. Some excuse, hardly sufficient I fear, can be offered for not expressing these doubts before this.

First, there was a considerable delay before a definitive description of the plan itself was made available by publication.[2] When the plan was published, it was apparent that a thorough, critical examination of it would require clarification of a good many of its rules of operation before their effect could be accurately evaluated. I do understand that some of the technical questions raised by the plan are under investigation, the results of which we may hope to see in due course. Meanwhile, I want to set down, in as non-technical a way as I can, my own observations on three main points.

MISUSE OF LOT PLOT

The first of these has to do with the widespread use of the lot plot plan in place of $\bar{X}$ and R charts in process control. It is true that Mr. Shainin designed his plan only for use in acceptance sampling by variables and he has stated repeatedly that he did not recommend its use in process control. How much effect his recommendations have had may be judged from the recent papers in *Industrial Quality Control* referred to above. In fact, I am afraid that the effect of these papers is to give most readers of *Industrial Quality Control* the green light for such use.

Now the lot plot plan does incorporate some of the features of $\bar{X}$ and R charts. On ten samples of five each it establishes a center line for $\bar{X}$'s and limit lines for them calculated from the average of the ten R's. But first, it is a fundamental and very important principle that until control is established for process variability, as shown by an R chart or its equivalent, one has, strictly speaking, no basis for setting limit lines on the X chart. *Only* if the process is definitely known to be in control with respect to variability is it safe to ignore the R chart.

Second, it must be remembered that, in any case, a total sample of 50 is somewhat inadequate as a basis for deciding that control exists, and estimates of $\bar{X}'$ and σ' made from it are at best first rough approximations to be confirmed and improved by more data. Of course, if the $\bar{X}$ chart based on 50 observations shows lack of control that is another matter.

Third, for the use of $\bar{X}$ and R charts in process control it is very important that a well designed

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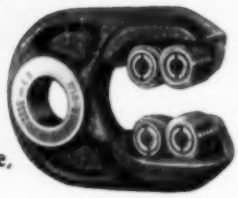
11 DIFFERENT STYLES TO CHECK ALL EXTERNAL THREAD ERRORS

- Diameters from No. 0 to 11-15/16"
- 3-1/2 to 80 Threads per Inch
- UNIFIED and American Standard Metric, Whitworth, British Assoc., Acme, Buttress and special thread forms



Pratt & Whitney Roll Thread Snap Gages combine "Go" and "Not Go" annular ribbed gaging rolls in a single unit for detecting all major errors in male threads including Lead, Pitch Diameter, Form, Roundness and Straightness. In operation they are very easy to use, and are much faster than other types. Products are easily gaged right on the machine without disturbing the work set up.

The two pairs of annular gaging rolls are rotatably mounted and revolve freely; wear is evenly distributed around the periphery of the rolls and results in a long accurate life. Each alternate rib on the rolls is recessed; this prevents the accumulation of chips and dirt that might otherwise interfere with the accuracy of the gaging operation.

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scheme of rational sub-grouping be used in taking the samples. I won't review this basic principle here—I will only remind readers of the general statement that for $\bar{X}$ and R charts in process control one should try to take samples in such a way as to make the variation within samples as small as possible and the variation between samples as large as possible. Since the lot plot plan was designed for acceptance sampling to be applied to lots received from a vendor, no recognition of the principle of rational sub-grouping is included in the instructions for its use. But is is apparent that many have adopted the lot plot plan as an instrument for process control following only the lot plot rules. Perhaps the following remark will help make what I am driving at here more clear. The lot plot limit lines, as applied to a consignment of items received from a vendor in which all order of production, all differences between machines, operators, shifts, materials, etc., are lost, tell only whether or not the sample of 50 was randomly taken from the lot (though a sample of 100 would be much better even for that purpose).

Finally, I am afraid that the use of the lot plot plan in process control lends encouragement to an already too widespread tendency to rely on a frequency histogram alone to judge whether or not a process is in control. It ought to be common knowledge that very often a very poor process can produce a quite decent looking histogram, especially if the sample is no larger than 50 or 100. I know that part of the trouble arises from forgetting the very important distinction between process limits and specification limits. If the process is already known to be in control, then one may use a frequency histogram based on a random sample to estimate its center and its spread, but to use such a frequency histogram to determine whether control exists is simply begging the question. In short, the use of the lot plot plan for process control is not statistical process control. It is safe *only* if the process is already in control.

THE OPERATING CHARACTERISTIC OF LOT PLOT

My second main point has to do with operating characteristic (OC) curves for the lot plot plan. It is superfluous to say that such curves

are an absolute necessity in the study of any sampling acceptance plan. For attributes sampling plans the construction of such curves is comparatively easy because the quality of any lot is determined by a single quantity, the fraction defective in that lot. But for variables sampling plans things are not so easily handled. It may be worthwhile to elaborate somewhat on what is involved.

For a variables plan the lot quality is specified by at least two quantities, usually $\bar{X}'$ and σ', and to get at the problem at all, it is ordinarily assumed that the distribution of the quality characteristic being measured in the lot can be reasonably closely approximated by a single normal curve. In other words, in general, *OC curves for variables acceptance plans apply only to fairly large lots from controlled processes.* What can happen when a particular plan is applied to an uncontrolled process is in the lap of the gods.

Let us assume then that we apply the lot plot plan only to lots normally distributed. If we show graphically the probability of acceptance (P_a) for each $\bar{X}'$ and σ', the OC curve becomes a surface in three dimensions. If we can add up the properly weighted P_a's for each combination of $\bar{X}'$ and σ' that gives the same fraction defective in the lot we can construct an ordinary two dimensional OC curve with P_a plotted against the quality level of incoming lots. For one-sided acceptance criteria such as $\bar{X} \leq \bar{X}' + k\,\sigma'$ this can be done at least approximately, and W. A. Wallis[3] and A. H. Bowker and H. P. Goode[1] have good treatments of this problem in print. But, as Professor Wallis remarks, the case of two-sided criteria is more troublesome.

We are concerned here with a two-sided criterion of acceptance; that both $\bar{\bar{X}} - \frac{3\bar{R}}{d_2}$ and $\bar{\bar{X}} + \frac{3\bar{R}}{d_2}$ fall within the specification limits. (I admit that Shainin says[2] that a lot failing to meet these requirements is not necessarily rejected but is "subject to special disposition by considering its probable effect as assembled." I do not see, however, how to give any quantitative evaluation to the effect of this provision.) I begin with the case in which the process (in control, I repeat) is such that its natural tolerances, $\bar{X}' \pm 3\sigma'$,

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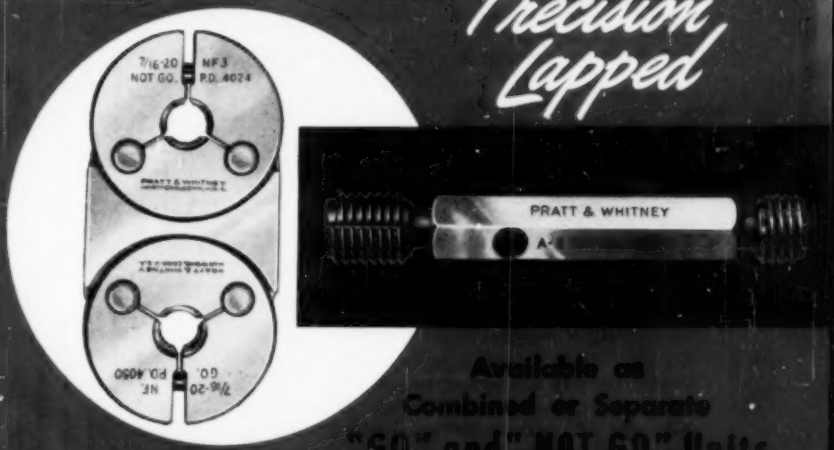

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precisely coincide with the specification limits. The process average fraction defective is thus 0.3 percent —in most circumstances practically negligible. I suppose that samples of 50 are drawn at random, that lot plots are constructed, and $\overline{\overline{X}}$ and $\overline{R}$ are calculated for each. (I also assume that no lot plot will look non-normal though the probability of this is not zero.) The probability problem we must solve is to find the chance that neither of $\overline{\overline{X}} \pm \frac{3\overline{R}}{d_2}$ will overstep $\overline{X}' \pm 3\sigma'$.

It might appear at first glance sufficient to find three times the standard deviation of $\overline{\overline{X}} + \frac{3\overline{R}}{d_2}$ and of $\overline{\overline{X}} - \frac{3\overline{R}}{d_2}$. (Incidentally this is not quite the same thing as finding three times the standard deviation of $\overline{\overline{X}} \pm 3\sigma$ which Shainin[2] gives in his Fig. 2, though I cannot tell how he used his results.) However, this is not enough since these quantities do not vary independently in samples but are more than negligibly correlated. (In fact, the coefficient of correlation between them is approximately —0.72. For more details concerning the derivation of this and other facts used in this section, see the appendix.) In view of this dependence one must use the joint distribution of $\overline{\overline{X}} + \frac{3\overline{R}}{d_2}$ and $\overline{\overline{X}} - \frac{3\overline{R}}{d_2}$ to find the probability that they simultaneously fall within the tolerance interval. This turns out to be about 0.38; that is, if the vendor's process has its true natural tolerances exactly agreeing with the print tolerances, then in 62 percent of random samples of 50 from that process at least one of the calculated lot limits will fall outside the specifications.

It is quite simple to get like results when the process spread, $6\sigma'$, is k times the tolerance interval. Table 1 exhibits them for several values of k.

TABLE 1

k ($6\sigma'$/tolerance)	P_a	Process % defective
0.60	1.000	0.00
.75	0.993	.00
.80	.961	.02
.90	.734	.09
1.00	.378	.27
1.10	.143	.65
1.20	.049	1.24
1.25	.024	1.64
1.50	.001	4.53

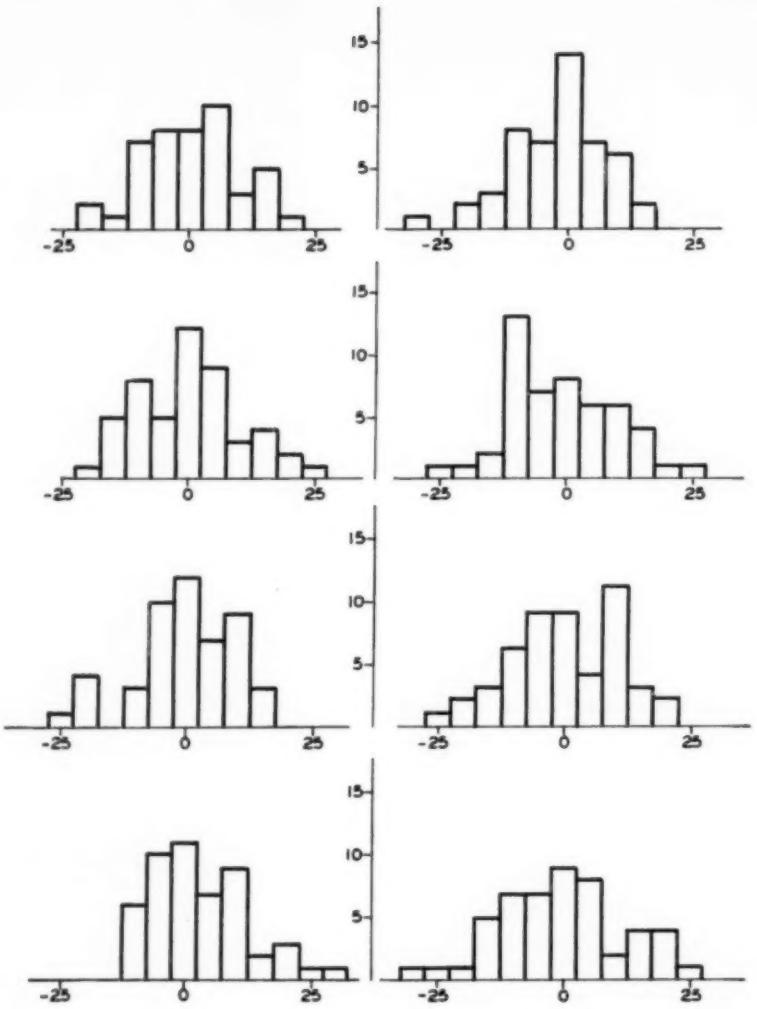
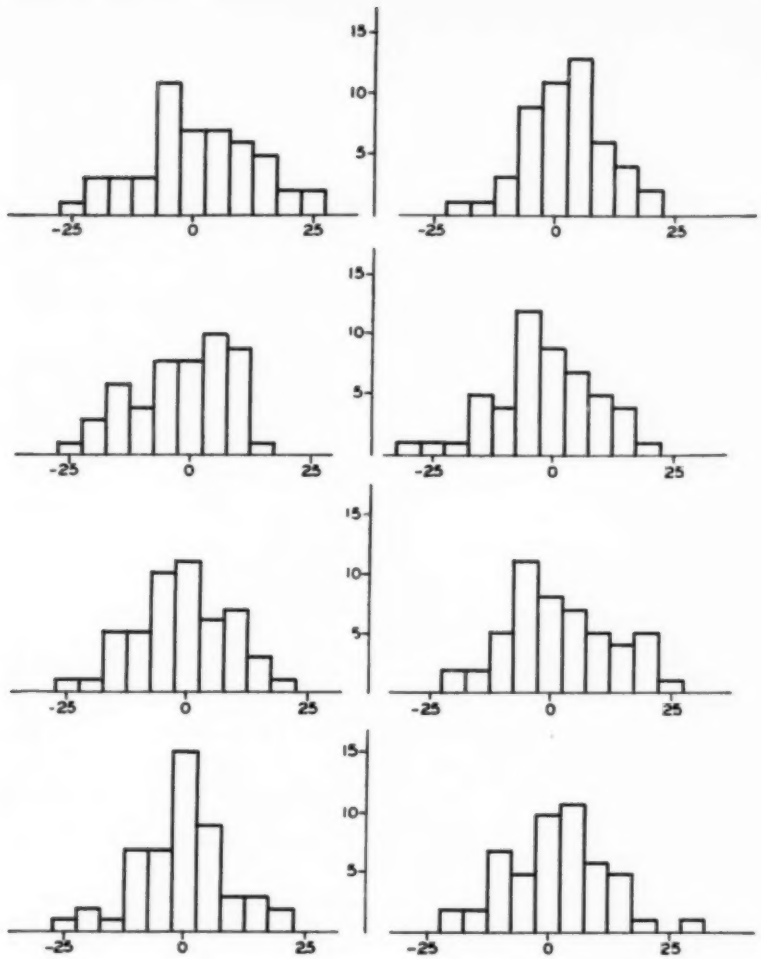


Figure 1—**Frequency Histograms**

To provide a rough check on these results and an illustration as well, I took the first 2500 drawings from Shewhart's normal bowl as listed in the appendix of his "Economic Control of the Quality of Manufactured Product," and divided them in the order of drawing into 50 samples of 50 each. The bowl contained 998 chips bearing marks from —3.0 to 3.0 by tenths with $\overline{X}' = 0$ and $\sigma' = 0.9954$. For simplification, I multiplied the numbers on the chips by 10. In each sample I calculated $\overline{\overline{X}} \pm \frac{3\overline{R}}{d_2}$ and noted how these lot limits fell with respect to $\pm 3\sigma' = \pm 29.86$, which are also the specification limits when k = 1. For the 50 samples there were 31 cases in which one or both of the lot limits fell outside the specifications. This is exactly the 62 percent given by the theory. By opening or closing the specifications, I got similar comparisons for the other values of k which are shown in Table 2.

TABLE 2

k ($6\sigma'$/tolerance)	Theoretical P_a	Number of the 50 lots accepted	Observed P_a
0.75	0.993	50	1.00
.80	.961	49	.98
.90	.734	36	.72
1.00	.378	19	.38
1.10	.143	3	.06
1.20	.049	1	.02



for 16 Samples of 50 each

It is apparent that the OC curve sketched from the data of Table 1 would not fall off quite as fast as the one Shainin[2] gives. However, I have considered only processes accurately centered on nominal, with varying dispersions. One could get an approximation to the complete OC curve by first using smaller steps between the values of k, then repeating the whole computation over again for each of a long enough succession of off-center values of X', again differing by small steps, and finally totalling and reducing to the proper scale all of the results that correspond to each small interval into which the fraction defective scale is divided.

Shainin gives no details of the way in which his OC curve, Fig. 21, was constructed. Meanwhile, there is no reason for doubting that the OC curve for this plan applied to lots from controlled processes is very like the quite steep curve Mr. Shainin gives. His plan was designed to be as effective as 100 percent inspection ordinarily is in detecting sub-standard lots. For lots from controlled processes I think it can be granted that he has succeeded quite well. But his plan sends for "special disposition" a very large percentage of lots that should not require any such treatment. (Presumably special disposition does not include 100 percent inspection.)

Admittedly if a vendor's process is controlled, is well centered, and has a spread which is not more than three quarters of the allowable tolerance interval, no randomly selected lots of the vendor's product will require special disposition. But, if the vendor's variability increases to the point of producing 0.1 percent defective material, it is to be expected that some 25 percent of his lots will not pass the criterion I have been discussing. Practically every 4-percent defective lot will require special treatment. People may have differing reactions to an OC curve like this; my main purpose in this section has been to point out its character with some emphasis.

DANGER OF DEPENDENCE ON HISTOGRAMS

My final main point is concerned with the way the lot plot plan performs when submitted lots are not large random samples from controlled processes. Is the "special disposition" referred to above included in the plan in a definite enough fashion for one to be able to discuss its effectiveness? The greater part of Mr. Shainin's instructions are devoted to measures for dealing with lots whose plots are not immediately satisfactory. I do not intend to try to discuss them in any detail; my principal concern is with the extent that they lean on frequency histograms constructed from 50 observations.

This is the feature of the lot plot plan that really made me sit up.

I thought I had learned in the course of some 25 years of teaching and working with statistical methods that one could not trust a frequency tabulation of 50 observations to tell one very much about the kind of universe sampled. If one knows that the population sampled obeys a distribution law of a fairly simple kind, then means and standard deviations calculated from a sample of 50 can give us useful estimates of the like quantities in the population. But this is a far cry from trying to tell whether a set of 50 observations came from an approximately normal universe or not, or indeed whether or not they came from the same universe. One of the prime lessons of statistical quality control is that one does not trust samples to give reliable information about a process until one has established that the process is in control. And I repeat, one does not tell whether

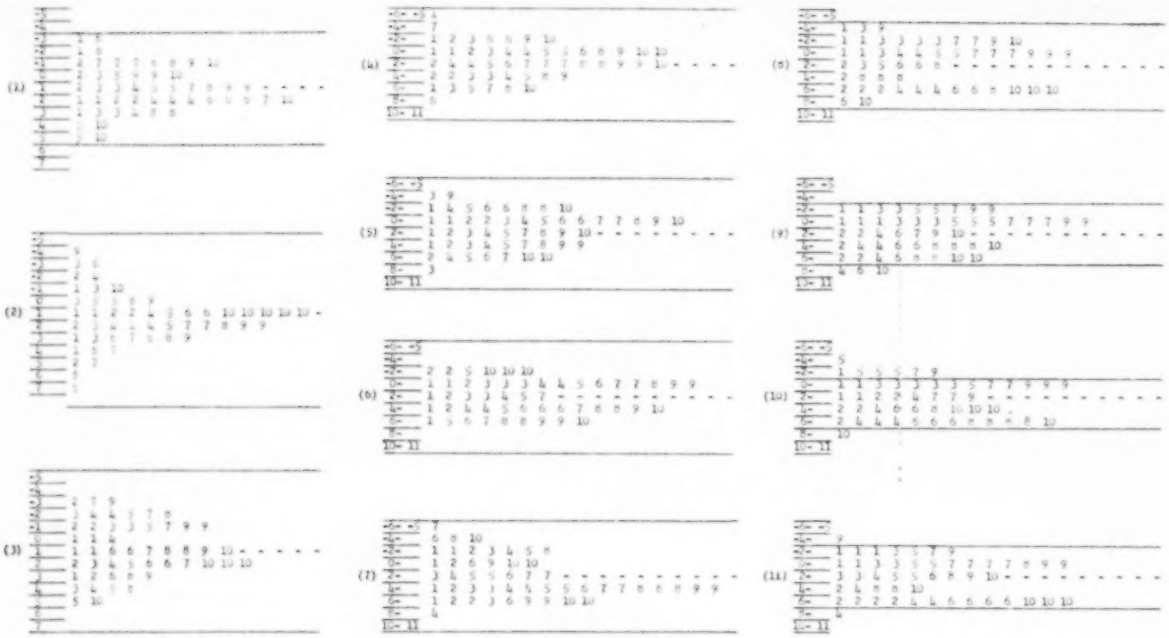


Figure 2—**Eleven Lot Plot Examples**

or not a process is in control from a frequency tabulation of 50 observations drawn at random from it.

The proof of the pudding is in the eating here. Let the reader try it himself.

In Fig. 1 are shown the frequency histograms of the first 16 samples of 50 from Shewhart's normal bowl. The reader is invited to estimate from their appearance how many of these are clearly constructed from random samples drawn from a normal universe.

In Fig. 2 are 11 lot plots. How many of the first seven came from normal bowls? None did. The first three came from a mixture of two normal bowls of 200 chips each with respective $(\bar{X}')$'s of 0 and 2 and a common σ' of 1.726. The next four came from a really bimodal universe —a mixture of two normal bowls as before with a common σ' of 1.726 but with $(\bar{X}')$'s of 0 and 5, nearly 3 σ' apart. If one is expecting the resulting lots plots to be bimodal too, these four are a bit disappointing. For the final four I took steps to secure bimodal lot plots. I used the same two bowls as in the second set but kept them separate and took samples of 5 first from one bowl and then from the other until I had five samples of 5 from each. Of course, this procedure is no longer lot plot but is an application of rational subgrouping.

I could go on at length on this part of lot plot procedure. For example, it is implicitly assumed in dealing with most of the various types of lot plots that they are samples from some definite type of a process. Then there is the matter of estimating the percent defective in a lot by the amount that the lot plot limits overstep the specification limits. To investigate the reliability of the method described is quite a good problem even if the population sampled is normal. But some actual sampling will throw some light on this. For my 50 samples from Shewhart's normal bowl with $k = 1$ no estimates showed as high as 4 percent defective in the bowl. But for $k = 1.25$ which made the bowl 1.64 percent defective, nine estimates were over 4 percent, one was 10 percent and another 14 percent.

Appendix

The approximate values of the coefficient of correlation given for

$$\bar{\bar{X}} + \frac{3\bar{R}}{d_2} \text{ and } \bar{\bar{X}} - \frac{3\bar{R}}{d_2}$$

and of the probabilities given in Table 1 were arrived at as follows:

We assume that the samples are composed of random drawings from a normal universe with $\bar{X}' = 0$ and $\sigma' = 1$ and that the specification limits are 3 and -3. Then $\bar{\bar{X}}$, being the mean of a sample of 50, will be normally distributed with a zero mean and $\sigma' = 1/\sqrt{50}$. Also in samples of five from a normal universe with $\sigma' = 1$, $\bar{R}' = d_2 = 2.326$ and $\sigma'_R = 0.864$. Though the distribution of R's is certainly not normal, $\bar{R}$'s which are the averages of ten R's will have a distribution reasonably well approximated by a normal curve. (The third standard moment of such an $\bar{R}$ is 0.147 and the fourth standard moment less three is 0.0169).

Now if x and y are statistically independent and normally distributed variables with $\bar{x}' = 0$ and $\bar{y}' = a$, then $x + y$ and $x - y$ jointly obey a normal bivariate distribution law with means a and $-a$, common variance $\sigma'_x{}^2 + \sigma'_y{}^2$ and covariance $\sigma'_x{}^2 - \sigma'_y{}^2$. Then identifying $\bar{\bar{X}}$ with x and $\frac{3\bar{R}}{d_2}$ with y, we have (since $\bar{X}$'s and $\bar{R}$'s in samples from normal are

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independently distributed, the same will be true of $\overline{\overline{X}}$ and $\overline{R}$) the result that $\overline{\overline{X}} + \frac{3\overline{R}}{d_2}$ and $\overline{\overline{X}} - \frac{3\overline{R}}{d_2}$ obey an approximately normal bivariate distribution law with means 3 and -3, the common variance,

$$\frac{1}{50} + \left(\frac{3}{d_2}\right)^2 (0.864)^2 = 0.02 + 0.124 = 0.144,$$

and covariance $0.02 - 0.124 = -0.104$. The coefficient of correlation of these two quantities is then approximately $-0.104/0.144 = -0.72$.

We want the probability that one or both of the inequalities $\overline{\overline{X}} + \frac{3\overline{R}}{d_2} > 3$ and $\overline{\overline{X}} - \frac{3\overline{R}}{d_2} < -3$ will be fulfilled. This is the complement of the probability that both of the inequalities $\overline{\overline{X}} + \frac{3\overline{R}}{d_2} - 3 \leq 0$, $\overline{\overline{X}} - \frac{3\overline{R}}{d_2} + 3 \geq 0$ hold simultaneously. This latter can thus be approximated as the volume under the upper left quadrant of a normal bivariate frequency surface with zero means, common variance 0.144 and covariance -0.104. This is 0.378 so that the probability sought is about 0.62.*

If now the normal distribution law for the process has a zero mean and $\sigma' = k$, the quantities $\overline{\overline{X}} + \frac{3\overline{R}}{d_2}$ and $\overline{\overline{X}} - \frac{3\overline{R}}{d_2}$ again obey an approximately normal bivariate distribution law with means $3k$ and $-3k$, common variance $0.144k^2$ and covariance $-0.104k^2$. In this case the probability that one or both of $\overline{\overline{X}} + \frac{3\overline{R}}{d_2} > 3$ and $\overline{\overline{X}} - \frac{3\overline{R}}{d_2} < -3$ hold is approximately the volume under this normal bivariate surface to the left of the line $\overline{\overline{X}} + \frac{3\overline{R}}{d_2} - 3k = 3(1-k)$ and below the line $\overline{\overline{X}} - \frac{3\overline{R}}{d_2} + 3k = -3(1-k)$. These quantities in standard (sigma) units are

$$\frac{3\,(1-k)}{k\,\sqrt{0.144}} = 7.92\left(\frac{1}{k} - 1\right)$$

$$\frac{-3\,(1-k)}{k\,\sqrt{0.144}} = -7.92\left(\frac{1}{k} - 1\right).$$

Using these, the values in Table 1 were found.

*See either: K. Pearson, *Tables for Biometricians and Statisticians*, Part II, London, 1931; or C. Nicholson, "The Probability Integral for Two Variables," *Biometrika*, Vol. 33, 1943, pp. 59—72.

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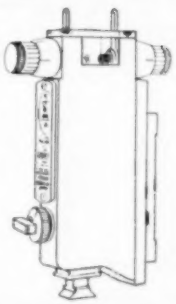

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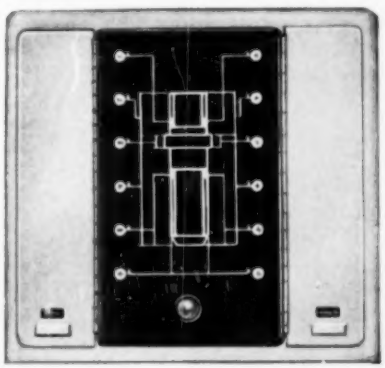

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The Use of Average and Range Charts to Control Material Consumption*

HOWARD R. BOLTON

Harrison Radiator Division, GMC

AVERAGE and range charts are frequently used in industry to control the dimensional accuracy of a piece or product. Parts are taken from a machine and checked with micrometers or some other measuring instrument and the dimensions are noted on a chart. Average and range values are computed and plotted on control charts. This procedure will tell us if the operation is in a state of statistical control. We say an operation is in statistical control if the variation is due to chance causes alone. The control chart will also tell us if the process is in control at the right level. Do our average values fall about the mean of the specification? Are they at the high or low limit of the specification, or are they outside of the tolerances established? The control chart is also used to detect trends. Are we drifting away from the desired average? The average and range charts can be used to analyze practically any process where direct measurements of weight, volume, or linear dimensions are used.

During the latter part of 1950 our Statistical Control department became involved in a discussion regarding solder consumption on radiator core assemblies. Solder consumption figures are established by the Production Records department and are used as a basis for ordering material. It was found that the actual solder consumption in the various core departments was exceeding the figures established by the Production Records section. Sample lots of material were checked throughout the production processing. In most instances it was found that the average solder consumption was above that allowed in the specification. During the course of analyzing the data, a simple graph was constructed showing the weight of solder consumed on each individual core. These values were plotted in the order in which the checks were made. The resulting charts showed in all cases that there was a downward trend throughout the test run. We believed there was sufficient evidence to warrant a quality control program to determine if the solder consumption could be controlled and at what level.

The decision to institute a quality control program on the solder consumption was not based entirely upon the fact that there was a difference of opinion regarding the standard established. We also took into consideration the fact that solder is an alloy of lead and tin, and during the latter part of 1950 tin was becoming a very critical item. We also gave consideration to the fact that solder is an expensive material and any saving in solder consumption would be a substantial cost reduction.

Radiator cores are made of copper. The various tube and center assemblies are stacked into core blocks, and the core blocks are securely held in place by frames. The frame holding the core block is run through an automatic soldering dip. This solder dip is a two-stage operation in which the copper is first cleaned by immersion in flux and then soldered by dipping in a pot of molten solder. This process is then repeated on the opposite side of the core. It was decided that we should weigh the core and frame assembly prior to, and immediately after, the dipping operation. The difference in weight would indicate the amount of solder accumulated by the core during the dipping operation.

There are five radiator core dips in operation and each core dip works two 8-hour shifts. In order to accumulate the data required, we assigned one inspector to each shift. It was this inspector's responsibility to get one sample each hour from each of the radiator core dips. These

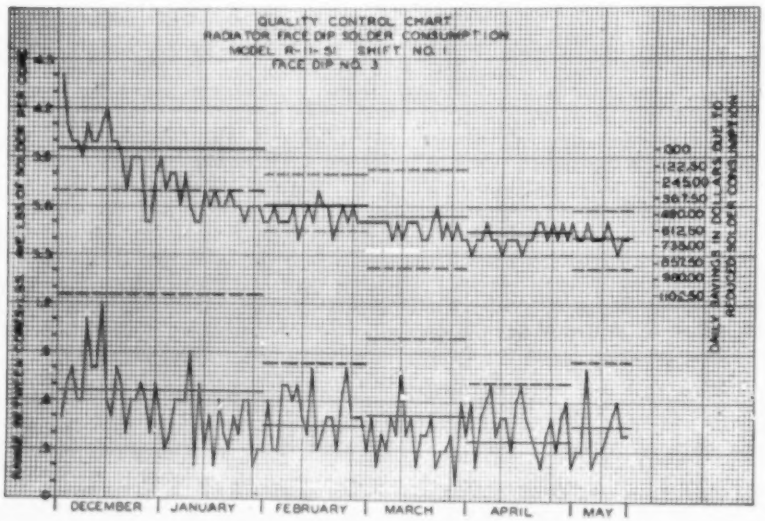

Figure 1—**Control Chart on Face Dip No. 3**

*Paper presented on the program of the Sixth Annual Convention of ASQC in Syracuse, New York, May 1952.

weights were recorded on forms provided. At the end of each 8-hour period, we had the actual weight of solder consumed on eight individual cores. This data was turned in daily to the Quality Control Office. The Quality Control Office computed the average and the range for each sample of eight cores. These points were plotted on average and range charts.

The control charts were located at each radiator dip. In Figure 1 is given an average and range chart for one radiator dip. This dip we have designated as Face Dip No. 3. On the chart, you will notice that we have plotted one point for each day's production. Separate charts were kept for each of the two shifts. The charts we have illustrated were taken from our regular production run from December 1950 through the middle of May 1951. You will note that during the months of December and Januahy there was a decided drop in the amount of solder being consumed. The average for the month of December 1950 was 3.95 lbs. per radiator. During the month of January 1951, the average had dropped to 3.62 lbs. per radiator. Each succeeding month shows a slight reduction in the amount of solder consumed. The latest average figure was 3.41 lbs. per radiator during May 1951. The process since that time has been holding very closely to the figure of 3.41 lbs. per radiator.

You may rightly wonder what caused this drop in the amount of solder being consumed. You may also wonder what redesign was made of the core or of the dip equipment to allow us to reduce the amount of solder being consumed. I can truthfully say that the only expense accrued throughout the program was that of gathering the data. This involved one inspector on each of the two shifts. The reduction in solder consumption was not made by the Quality Control department. We merely indicated the progress being made.

Any reduction in solder consumption can be traced back directly to dip operators and to production supervision in the various departments. The production foremen were definitely in favor of this program. They would naturally have a vital interest in it, inasmuch as their performance is indicated by the control they have of the productive labor and materials and equipment they are responsible for. We found that the dip operators

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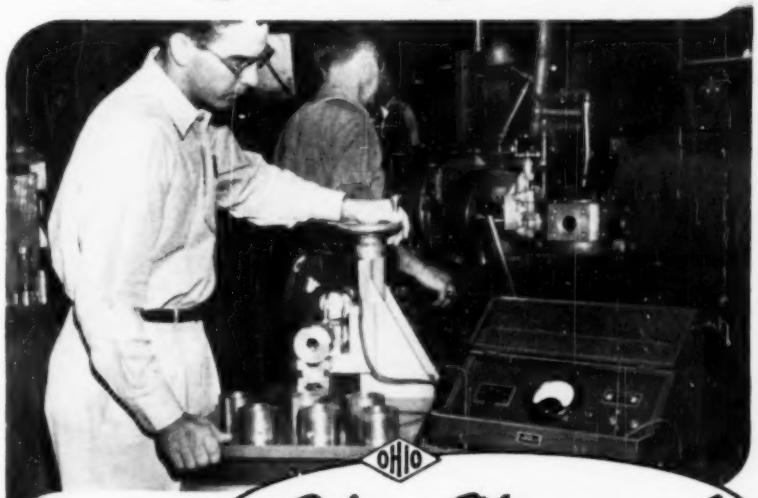

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were very glad to get this information. It gave them a running picture of how well their dips were operating. We found that they took a more active interest and pride in the job they were doing. They paid closer attention to the dip and made more frequent checks on the depth of solder and the temperature of the solder being used. We found that they could more closely control the depth of the solder in the dip by more frequently cleaning out the overflow vent. This they performed religiously.

The cost savings I believe speak for themselves. In Figure 1 you will notice a scale along the right-hand side of the average chart. We have used a base period of the December 1950 average and called this zero. Any reduction in the average value below this has been shown on this scale. You will note that the latest average of 3.41 lbs. per core means a saving of approximately $621.00 per day from this one dip. When you consider that at that time we had five dips in operation and the only expense involved in accumulating this data was 16 hr. per day inspection time, plus approximately one hour quality control time, I think we can safely say this program has paid its own way.

During the period of April and May 1951 a series of quality assurance tests were made in conjunction with the solder consumption program. The purpose of this investigation was to assure us that we were not reducing the quality of the radiator cores being produced due to the fact that we were using less solder. This investigation involved a close check on the number of small seeper face leaks which are found on radiator cores prior to the test and repair operation. This is a normal production repair operation required on all radiators. During this two-month investigation we did not find any deterioration of quality in this respect. A close analysis was made of the percentage of solder bond being obtained with these lower solder consumption figures. Our analysis disclosed that the solder bond values were consistently running high and there was no measurable difference in the heat dissipation of the cores with the lower solder consumption. Based on these analyses we definitely proved that the reduction in solder consumption had not affected the quality of the finished product in any respect.

I hope this discussion may show you one more tool you can use in the never-ending job of trying to stretch supplies of critical material. The story has been very simple, and I am sure that if you look at your processes you will find places where this tool can be applied in your organization.

Practical Aids

ELLIS R. OTT, Editor

Send your "Practical Aid" contribution to:
Dr. Ellis R. Ott
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Confidence Limits on Process Capabilities

IRVING W. BURR

Purdue University

INTRODUCTION

In process capability studies and, in fact, in most control chart applications, when we have succeeded in getting good control, we want to know what the true process mean $\overline{X}'$ and standard deviation σ' are. The usual estimates of these are respectively $\overline{\overline{X}}$ and either $\overline{R}/d$ or $\overline{\sigma}/c_2$.[1] These are good as far as they go, but they do not tell the whole story. We would in general like to know how much error is to be expected in our estimates of X' and σ'. The answer helps us interpret the meaning of our estimates.

AN EXAMPLE

For an illustration we use the well-known rheostat knob data.[2] For the first 44 samples of five each, we find $\overline{\overline{X}} = 0.14100$ in. and $\overline{R} = 0.00823$ in. for the dimension from the back of the plastic disk to the far side of a pinhole. All 44 points on each chart, $\overline{X}$ and R, *were inside the control limits,* hence we are in a good position to estimate process capabilities:

$\overline{X}'$ estimated to be $\overline{\overline{X}} = 0.14100''$

σ' estimated to be $\dfrac{\overline{R}}{d_2} = \dfrac{0.00823''}{2.326} = 0.00354''$

These are what is known as "point estimates." We now want to set "confidence limits" around these single values.

A. Confidence Limits for $\overline{X}'$

Although any desired degree of confidence may be used, we shall choose 90 percent for this illustration. Then using the formulas given in the next section we have

$$\overline{\overline{X}} \pm t\frac{\overline{R}}{d_2\sqrt{kn}} = 0.14100'' \pm \frac{1.64 \times 0.00823''}{2.326\sqrt{44 \times 5}}$$

$$= 0.14100'' \pm 0.00039'' = 0.14061'', 0.14139''$$

for $\overline{X}'$, where the value of t is for a central area of 90 percent. (See the table in the next section.) Thus 90

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percent of the time, limits so determined for $\overline{X}'$ will in fact contain the actual true $\overline{X}'$. In this sense then we have 90 percent confidence that the true process average lies between 0.1406 in. and 0.1414 in.

B. Confidence Limits for σ'.

For σ' we have the limits

$$\frac{\overline{R}}{d_2 + \left(t \frac{D_2 - d_2}{3\sqrt{k}} \right)} = \frac{0.00823''}{2.326 \pm 1.64 \frac{4.918 - 2.326}{3\sqrt{44}}}$$

$$= \frac{0.00823''}{2.326 \pm 0.214} = 0.00324'', 0.00390''$$

We thus have 90 percent confidence that the true process standard deviation lies between 0.0032 in. and 0.0039 in., because limits so determined will in fact contain the true σ', 90 percent of the time.

Such information as we have just obtained tells us much about relative accuracy of our estimates.

THE FORMULAS

We use the following notation:

k = number of samples

n = number of measurements in each single sample

t_P = normal curve value for a central area or confidence coefficient P, e.g. 90 percent. See table below for values of t_P

B_2, D_2, c_2, d_2, = control chart constants (Reference 1)

Formulas for P confidence limits from $\overline{X}$ and R charts which are in control:

$$\text{For } \overline{X}': \quad \overline{\overline{X}} \pm \left(\frac{t_P \, \overline{R}}{d_2 \sqrt{kn}} \right) \tag{1}$$

$$\text{For } \sigma': \quad \frac{\overline{R}}{d_2 \pm \left(t_P \frac{D_2 - d_2}{3\sqrt{k}} \right)} \tag{2}$$

Formulas for P confidence limits from $\overline{X}$ and σ charts in control:

$$\text{For } \overline{X}': \quad \overline{\overline{X}} \pm \left(\frac{t_P \, \overline{\sigma}}{c_2 \sqrt{kn}} \right) \tag{3}$$

$$\text{For } \sigma': \quad \frac{\overline{\sigma}}{c_2 \pm \left(t_P \frac{B_2 - c_2}{3\sqrt{k}} \right)} \tag{4}$$

In using formulas (1) to (4) we should have k at least 20, kn at least 100, and reasonably normal distributions.

Table of Normal Curve Constants

Confidence P:	.80	.90	.95	.98	.99	.999
t_P	1.28	1.64	1.96	2.33	2.58	3.29

MATHEMATICAL APPENDIX

We have in the foregoing assumed a normal population. Suppose now that we knew σ'. Then since $\sigma'_{\overline{X}} = \frac{\sigma'}{\sqrt{n}}$, we have that $\sigma'_{\overline{\overline{X}}} = \frac{\sigma'}{\sqrt{kn}}$. Then, using the normal curve, we have that the probability of

$$\overline{X}' - t_P \frac{\sigma'}{\sqrt{kn}} < \overline{\overline{X}} < \overline{X}' + t_P \frac{\sigma'}{\sqrt{kn}} \tag{5}$$

is P. That is, in the long run, the proportion P of our $\overline{\overline{X}}$'s will lie between these limits.

Now let us consider the first two terms of the double inequality. From them we derive that

$$\overline{X}' < \overline{\overline{X}} + t_P \frac{\sigma'}{\sqrt{kn}}$$

Similarly the second and third terms yield

$$\overline{\overline{X}} - t_P \frac{\sigma'}{\sqrt{kn}} < \overline{X}'$$

Putting these two together we have

$$\overline{\overline{X}} - t_P \frac{\sigma'}{\sqrt{kn}} < \overline{X}' < \overline{\overline{X}} + t_P \frac{\sigma'}{\sqrt{kn}} \tag{6}$$

Now (6) will be true when, and only when, (5) is true. Hence, since (5) stands to be true P of the time, so will (6).

Now the only trouble with the confidence limits (6) is the presence of the unknown σ'. Hence we substitute either $\overline{R}/d_2$ or $\overline{\sigma}/c_2$ for σ' and obtain (1) and (3), respectively.

Next let us consider the limits for σ' from $\overline{R}$. First we have

$$\text{UCL}_R: \quad D_2 \, \sigma' = \overline{R}' + 3 \, \sigma'_R$$

$$\text{CL}_R: \quad d_2 \, \sigma' = \overline{R}'$$

$$(D_2 - d_2) \, \sigma' = 3 \, \sigma'_R$$

Hence

$$\sigma'_R = \frac{(D_2 - d_2) \, \sigma'}{3}$$

The standard deviation of an average of k values of R will be $1/\sqrt{k}$ times this, that is,

$$\sigma'_{\overline{R}} = \frac{(D_2 - d_2) \, \sigma'}{3\sqrt{k}}$$

Now assuming normality of distribution, which will be sound with k and kn big enough, we can say that the probability of $\overline{R}$ lying between

$$\overline{R}' \pm t_P \, \sigma'_{\overline{R}}, \text{ or}$$

$$d_2 \, \sigma' \pm t_P \frac{D_2 - d_2}{3\sqrt{k}} \, \sigma'$$

is P. Thus the probability of the double inequality

$$\left(d_2 - t_P \frac{D_2 - d_2}{3\sqrt{k}}\right) \sigma' < \overline{R} < \left(d_2 + t_P \frac{D_2 - d_2}{3\sqrt{k}}\right) \sigma' \tag{7}$$

being true is P. The first two terms of (7) give

$$\sigma' < \frac{\overline{R}}{d_2 - t_P \frac{D_2 - d_2}{3\sqrt{k}}}$$

while the last two give

$$\frac{R}{d_2 + t_P \dfrac{D_2 - d_2}{3\sqrt{k}}} < \sigma'$$

Putting these together we obtain

$$\frac{R}{d_2 + t_P \dfrac{D_2 - d_2}{3\sqrt{k}}} < \sigma' < \frac{R}{d_2 - t_P \dfrac{D_2 - d_2}{3\sqrt{k}}} \qquad (8)$$

Such limits will contain the true σ' a proportion P of the time. The limits (4) for σ' from $\bar{\sigma}$ are derived in exactly similar manner.

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1. "Control Chart Method of Controlling Quality During Production," Z1.3 American Standards Assn., 1942.
2. Working, H. and E. G. Olds: "Manual for an Introduction to Statistical Methods of Quality Control in Industry, An Outline of a Course of Lectures and Exercises," War Production Board, Office of Production Research and Development, April, 1944.

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BIBLIOGRAPHICAL

SELECTED REFERENCES ON STATISTICS, THE THEORY OF TEST CONSTRUCTION, AND FACTOR ANALYSIS, Frances Swineford
(School Review—v. 60, n. 8, Nov. 1952, p. 491)

A list of about 64 books dealing with the application of statistics to education and psychological testing. Contains a short description of the contents of each volume.

APPLICATION—AUTOMOTIVE INDUSTRY

STATISTICAL QUALITY CONTROL—WATCHDOG OF FORD FINISHES, Frank L. Bonem
(Products Finishing—v. 17, n. 8, May 1953, p. 22)

Statistical Quality Control methods are used extensively throughout the operation in the Ford, Dearborn Assembly Plant. These include sampling plans and p charts on received material, various control charts during production, and control of finish. Finish control includes p chart for defects and X and R charts for paint thickness. Frequency distributions of prime coat thickness are also shown.

STATISTICAL QUALITY CONTROL MAKES TOLERANCES BEHAVE, Irvin W. Schoeninger, Globe-Union, Inc., Milwaukee, Wis.
(SAE Journal—v. 61, n. 6, June 1953, p. 23)

This is a report of a panel discussion on "Quality Control" held at the SAE National Tractor Meeting, Milwaukee, September 1952.

A series of questions and answers on the use and value of process control and of acceptance sampling and consumer-vendor relations are given.

APPLICATION—MEDICAL AND DRUG INDUSTRY

STATISTICAL QUALITY CONTROL IN THE INSPECTION LABORATORIES, R. H. Noel, Director of Product Coordination, Bristol Laboratories, Inc., Syracuse, New York
(Drug and Allied Industries—v. 39, n. 2, Feb. 1953, p. 14)

In this article Mr. Noel discusses the problem of quality control within the laboratory. The fact that small samples may be misleading is noted, and that some measure of the error in such work must be known. Two interesting nomographs are given from which confidence limits can can be read for small numbers of replicate tests. This is the 5th and concluding article of Mr. Noel's series. The earlier articles in this series were reported in in the November 1952 and July 1952 Bibliography Sections.

APPLICATION—METALLURGICAL INDUSTRY

SYMPOSIUM ON THE CONTROL OF QUALITY IN THE PRODUCTION OF WROUGHT NON-FERROUS METALS AND ALLOYS

1. The Control of Quality in Melting and Casting (Journal of the Institute of Metals—v. 81, Mar. 1953)

This Journal contains the following articles:

"The Principles of Technical Control in Metallurgical Manufacture" by A. R. E. Singer

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"The Control of Quality in the Production of Brass Ingots and Billets" by M. Cook and C. L. M. Cowley

"The Control of Quality in Melting and Casting Copper and High-Conductivity Copper-Base Alloys" by J. Sykes

"The Control of Quality in the Casting of Zinc and Zinc Alloy Rolling Slabs and Extrusion Billets" by M. C. W. Roberts and B. Walters

"The Control of Quality in the Melting and Casting of Aluminum Alloys for Working" by R. T. Staples and H. J. Hurst

"The Control of Quality in Melting and Casting Magnesium Alloys for Hot Working" by R. G. Wilkinson and S. B. Hirst

In general, these articles discuss the metallurgical techniques of quality control. Mr. Singer, in his introductory article, does present some discussion of the statistical aspects of the control of quality and the statistical methods used.

APPLICATION—METAL WORKING

QUALITY CONTROL ON SCREW MACHINES . . . A NEED AND THE ANSWER, W. N. Nordquist (Tooling and Production—v. XIX, n. 2, May 1953, p. 52)

The Manufacturing Standards Committee of the National Screw Machine Products Association has initiated a program to develop an understanding and use of statistical quality control among its members. This article describes some of the thinking of this committee in the standardization of certain approaches. The use of sampling tables, records and reports, and classification of defects is discussed.

APPLICATION—MISCELLANEOUS

STATISTICAL ANALYSIS OF TRICKLING FILTER DATA. John M. Fairall, State Board of Health, Madison, Wisconsin (Sewage and Industrial Wastes—v. 24, n. 11, Nov. 1952, p. 1358)

Normal probability paper and confidence limits are used in a study of two experimental filters. Attention is called to the fact that chance alone can give misleading high or low values.

QUALITY CONTROL AS APPLIED TO FIRE CLAY AND ALUMINA-DIASPORE FIRE-CLAY BRICK, E. B. Hunt and A. R. Lesar (American Ceramic Society Bulletin—v. 32, n. 3, March 1953, p. 74)

A general discussion of the need for, and factors effecting quality control in this industry. Not SQC.

This publication also has the following articles that discuss quality control in terms of the technological problems of the product.

"Fundamentals of Control Testing" by S. M. Swain

"Control System Problems with Semisilica Brick" by G. Bickley Remmey

"Quality Control of Ladle Brick" by J. A. Roslund

STATISTICAL QUALITY CONTROL IN THE FINISHING INDUSTRY, Bryant W. Pocock (Products Finishing—v. 17, n. 6, Mar. 1953, p. 22)

Thickness of paint on fenders, or pH determinations, form normal distribution curves as do other variables. X and R control charts are made of this data. In this way a mathematical system can be applied to efforts of a group to maintain consistent acceptable processes at lowest possible cost. Applications of these techniques are described and discussed.

STATISTICS—A USEFUL TOOL FOR THE EXAMINATION OF CORROSION DATA, Charles F. Lewis, Cook Heat Treating Company, Houston, Texas (Corrosion—v. 9, n. 1, Jan. 1953, p. 38)

"All empirical data are probable only." With this statement as a starting point, statistical techniques to analyze and evaluate observed data are developed. The article discusses the frequency distribution; preparation, plotting and interpretation of data; confidence limits; and sample size for a predetermined degree of precision.

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DELAY CURVES FOR CALLS SERVED AT RANDOM, John Riordan
(Bell System Technical Journal —v. 32, n. 1, Jan. 1953, p. 100)

Curves and tables for the probability of delay of calls under certain conditions. The theoretical development of the computation is given.

MANAGEMENT AND PERSONNEL, GENERAL

QUALITY CONTROL AND THE RESEARCH FUNCTION, O. P. Beckwith, Alexander Smith, Inc., Yonkers, New York
(Textile Research Journal—v. 23, n. 3, Mar. 1953, p. 197)

This article presents in some detail the relationship between quality control and research in the textile industry. Organization and relationship are outlined. The services performed by quality control for research, and the guidance of quality control by research are discussed. Both of these, of course, are necessary to effective production.

CONCEPTS OF QUALITY CONTROL, W. R. Purcell, Rath & Strong, Boston, Mass.
(TAPPI—v. 36, n. 1, Jan. 1953, p. 1)

The Statistics Committee of the Technical Association of the Pulp and Paper Industry can utilize the findings of the ASQC to solve its own problems. One such problem is the difference in QC outlook of supervisory and technical staffs. To overcome this difference requires mutual understanding of certain concepts.

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1. Economic Quality Balance
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7. Acceptance Sampling Vs. Control Sampling
8. Fundamental Process Control
9. Process Capabilities
10. Reasoning from Sample to Process to Product
11. Satisfaction or Action
12. Dynamic QC Vs. Static QC
13. Facts Vs. Opinions
14. Quality of Data
15. Natural Law of Variability

INDUSTRIAL MANAGEMENT

BUSINESS STATISTICS GOING PH. D.
(Business Week—May 30, 1953, p. 96)

Comments on the introduction of statistical (sampling and operations research) techniques to business management. Applications discussed include:

Financial control through sampling

Sampling inventories

Advertising estimates of factors through a ranking system

STATISTICS

FURTHER NOTES ON THE PRODUCTIVITY OF MACHINES REQUIRING ATTENTION AT RANDOM INTERVALS, F. Benson
(Royal Stat. Soc. Journ.—B, v. 14, n. 2, 1952, p. 200)

SOME RECENT WORK ON SYSTEMATIC EXPERIMENTAL DESIGNS, D. R. Cox
(Royal Stat. Soc. Journ.—B, v. 14, n. 2, 1952, p. 211)

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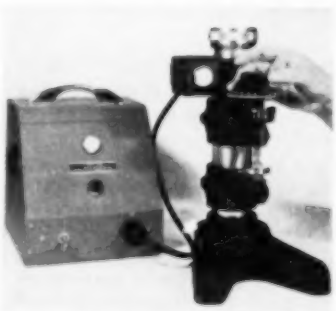

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(Jorun. of Am. Stat. Assoc.—v. 48, Mar. 1953, p. 79)

NON - LINEAR FUNCTIONAL RELATIONSHIP BETWEEN TWO VARIABLES WHEN ONE VARIABLE IS CONTROLLED, R. C. Geary
(Journ. of Am. Stat. Assoc.—v. 48, Mar. 1953, p. 94)

AUTOMATIC MACHINE METHOD OF CALCULATING CONTINGENCY, J. Skory
(Biometrics—v. 8, Dec. 1952, p. 380

ON THE THEORY OF SYSTEMATIC SAMPLING, W. G. Madow
(Annals of Math. Stat.—v. 24, Mar. 1953, p. 101)

DISTRIBUTION-FREE TESTS OF FIT FOR CONTINUOUS DISTRIBUTION FUNCTIONS, Z. W. Birnbaum
(Annals of Math. Stat.—v. 24, Mar. 1953, p. 1)

SIMPLE METHOD FOR IMPROVING SOME ESTIMATORS, L. A. Goodman
(Annals of Math. Stat.—v. 24, Mar. 1953, p. 114)

OPERATIONS RESEARCH

OPERATIONS DIAGNOSIS IN RESEARCH PLANNING, Clyde Williams
(Science—v. 116, n. 3026, Dec. 26, 1952, p. 3)

A brief discussion of the advantages to be gained by diagnosing the factors that enter into the planning of research. Operations Diagnosis is a combination of operations research and engineering economics.

TOWARD A PHILOSOPHY OF OPERATIONS RESEARCH, Gerard Hindrichs
(Philosophy of Science—v. 20, n. 1, Jan. 1953, p. 59)

Mr. Hindrichs discusses the underlying thinking of Operations Research and its basic philosophy. The underlying limitations of various scientific and human activity that give rise to the need for this group technique are discussed. Examples of its use and an interesting series of references are included.

NEW MATHEMATICAL METHODS IN OPERATIONS RESEARCH, B. O. Koopman

SOME NEW STATISTICAL TECHNIQUES APPLICABLE TO OPERATIONS, R. L. Ackoff
(Journal of the Operations Research Society of America—v. 1, n. 1, Nov. 1952)

OPERATIONS RESEARCH IN AGRICULTURE, C. W. Thornwaite

THE RELIABILITY OF AIRBORNE RADAR EQUIPMENT, David M. Boodman

THE MONTE CARLO METHOD AS A NATURAL MODE OF EXPRESSION IN OPERATIONS RESEARCH, Gilbert W. King

THE OPTIMUM DISTRIBUTION OF EFFORT, Bernard O. Koopman

THE EFFECT OF PROMOTIONAL EFFORT ON SALES, John F. Magee
(Journal of the Operations Research Society of America—v. 1, n. 2, Feb. 1953)

In addition to the above articles, this publication describes the first national meeting of the Operations Research Society of America at the National Bureau of Standards, Washington, D. C., December 17, 1952.

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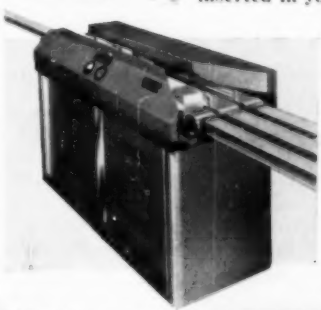

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The Pittsburgh Section of ASQC has decided that the time has come to begin making management aware of available scientific methods for analyzing and controlling many of its problems. This program for enlightenment begins with a two day conference on "Management Controls" to be held in Pittsburgh on Thursday and Friday, October 1-2, 1953.

The conference program has been designed to illustrate and promote thinking about applications of statistical quality control methods in the fields of industrial engineering, cost reduction, market analysis, inventory control, and production planning. There will be a full-time, two-day educational series for those who wish to understand the basic statistical control techniques. To provide ample opportunity for questions and discussion, each speaker will be allotted an hour and a half for his subject.

In addition to notable banquet and luncheon speakers, the conferees will be able to hear and question the following authorities:

Wilbur Hoehing, Westinghouse Electric Co.
"Statistical Inventory Control"

Norman R. Moss, Firth Sterling
"Determining Sample Size in Marketing Surveys"

Fred C. Leone, Case Institute of Technology
"Operations Research"

R. E. Wagenhals, Timken Roller Bearing
"Inspection Sampling"

Bob Mellon, Gulf Oil Corporation
"The Statistical Approach to Cost Reduction Problems"

Charles A. Bicking, Office of Chief of Ordnance, U.S. Army
"Management Uses of Statistics"

D. H. W. Allen, Steel Co. of Canada
"Using IBM Equipment on Correlation Problems"

Dale Lobsinger, United Air Lines
"Applying SQC to Clerical Work and Non-Manufacturing Operations"

Dorian Shainin, Rath & Strong, Inc.
"Lot Plot Method of Acceptance Sampling"

Leonard Seder, Gillette Safety Razor Co.
"Systematic Procedure for Attaining Necessary Process Capability."

Arthur Bender, General Motors
"What Are Your Chances?"

Information about the conference may be obtained by writing to Bob Mellon, Gulf Building, Pittsburgh 19, Pa.

GEORGIA TECH ADVANCED SHORT COURSE

An eight-day intensive advanced training course in statistical methods of quality control will be offered by the Georgia Institute of Technology at Atlanta, Georgia, November 11-19, 1953.

Techniques applicable to all industries will be studied, but those of special interest to the textile industry will be emphasized. This course is designed for those who have training equivalent to that afforded by one of the standard basic short courses in statistical quality control. Enrollment will be open to all who desire to learn more about the statistical approach to industrial problems.

Tuition for the course is $150 which includes all texts, supplies and a class banquet. Further information about the course can be obtained from: C. H. Taylor, Coordinator, Short Courses and Conferences, Engineering Extension Division.

EIGHTH MIDWEST QC CONFERENCE

The Eighth Midwest Quality Control Conference which is scheduled for October 8-9, 1953, will be held in the Masonic Temple at Davenport, Iowa.

The conference is being sponsored by the 18 sections of the Midwest region in cooperation with the Davenport Chamber of Commerce, the Iowa Manufacturers' Association and the Associated Industries of the Quad-Cities. General chairman of the conference is E. L. Fay, Deere & Company, Moline, Illinois.

This conference will offer a splendid opportunity for those who attend to profit from clear, concise and concentrated presentations of the latest techniques and methods as developed in actual industrial experience. For those interested in the fundamentals a two-day basic training course will be held concurrently with the clinic sessions. This course will be conducted by a staff of industry and university personnel. In addition, a ladies' program is being planned which will include several features of special interest to them.

The registration fee for the two-day conference will be $17.50. Tickets for the ladies' program will be $5.00. We suggest that you make your reservations as soon as possible to insure your attendance. Requests for Advance Registrations should be directed to H. E. Grieshaber, Aluminum Company of America, Davenport, Iowa.

NOMINATIONS FOR THE 1952-53 BRUMBAUGH AWARD

In accordance with the provisions governing the Brumbaugh Award, nominations for the 1952-53 candidates are now in order. The Brumbaugh Award Committee earnestly seeks the advice of the Society membership in determining the award winners. Your individual recommendation should be in the hands of the committee chairman, Halsey H. Kent, Eastman Kodak Company, Rochester, N.Y., by November 1, 1953.

A lengthy letter in support of your nomination is not necessary. Just use the following simple form:

I recommend that the paper written by.....

and published in the ..... issue of IQC under the title of

.....be awarded the 1952-53

Brumbaugh Award.

(signed)

.....

The papers which are eligible for this year's award are those that appeared in Vol. IX of IQC—July 1952–May 1953.

AMERICAN SOCIETY NEWS

Two society groups held meetings at the Benjamin Franklin Hotel in Philadelphia on May 29, the major actions of which have not yet been reported here. First was the meeting of the incoming Board of Directors for 1953-54 which was held primarily to elect the five executive directors who are to serve on the Executive Committee this year. Second was the meeting of the new Executive Committee which was held to discuss preliminary plans for the coming year.

1953-54 BOARD OF DIRECTORS MEETING

This was the first Board of Directors meeting held under the Society's reorganization plan which was embodied in the constitutional changes authorized this year by the membership.

Under the old plan the Board of Directors itself was composed of one national director from each section who was elected along with the other section officers. All of the national directors from each region would in turn elect one of their members as the regional director who would serve on the Executive Committee and who would specifically represent that region.

Under the new plan, which was set up partly to bring the number of persons serving on the Board of Directors within the legally allowable limit and partly to provide a more uniformly integrated organization, the board members are elected on the basis of districts having the same geographical significance as the old regions. The number of board members to be elected in each district is prorated on the basis of the total membership in the district, and in general this number is somewhat less than the number of sections in the district. Finally, the five executive directors who serve on the Executive Committee are elected as a group by the entire board rather than individually by the members from each district.

Since this was the first board meeting in the history of the society devoted to this purpose, there was considerable discussion about the procedures and method of balloting. Receiving particular attention in the discussions was the subject of the qualifications of candidates. It was felt that these qualifications had to be carefully examined in the

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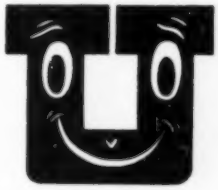

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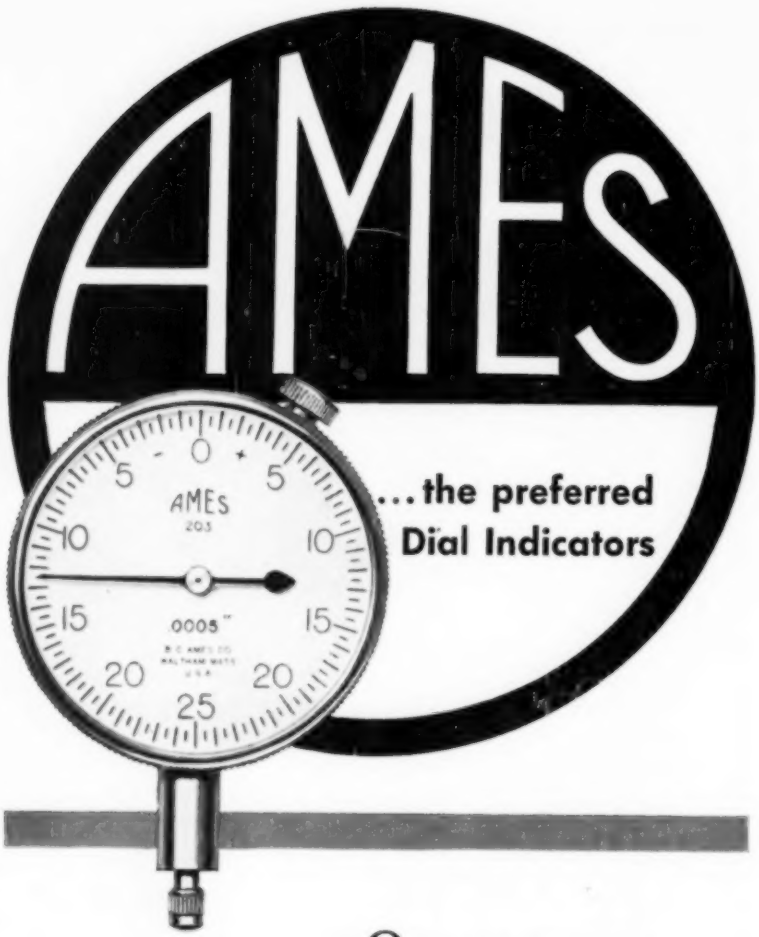

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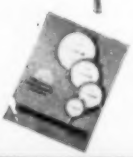

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light of the fact that the executive directors are now to serve the society on a national basis rather than serve it as the representative of a specific district.

After the ground rules had been worked out, the following directors were elected to the Executive Committee:

Max Astrachan
USAF Institute of Technology
Wright-Patterson AFB
Dayton, Ohio

H. J. Becker
American Steel and Wire Company
Waukegan, Illinois

E. C. Harrington, Jr.
Monsanto Chemical Company
Springfield, Massachusetts

Dale Lobsinger
United Airlines Inc.
Denver, Colorado

E. E. Schiesel
Mattatuck Manufacturing Company
Waterbury, Connecticut

INCOMING EXECUTIVE COMMITTEE MEETING

A tentative budget for the 1953-54 fiscal year of slightly more than $77,000 dollars each for income and expense was reviewed. During the accompanying discussions it was decided not to publish a Yearbook this year.

The problems of the Automotive Technical Committee were discussed briefly. It was agreed that the Executive Committee at its next meeting in Ann Arbor would meet with several of the automotive people to discuss the future plans of the technical committee. One of the things this group is planning is an Automotive Technical Supplement for later this year. Work on the supplement material has already begun.

The Executive Committee voted its intent to act favorably on a request from the Textile Division for a loan of funds to hold a conference at Raleigh, N. C., in February 1954. Papers presented at this conference will be published as a set of Conference Papers rather than as another Textile Technical Supplement. It is planned that the loan will be repaid from the proceeds of the conference.

The Executive Committee received the report of the Editorial Board on the proposal to publish *Industrial Quality Control* on a monthly basis.

Specifically the Board decided to hold its recommendation in abeyance until information could be obtained bearing on (1) a clear cut desire on the part of ASQC members, and (2) the necessity to render a 12-issue service to advertisers. To help in deciding the first of these issues and to secure other accessory information for the guidance of the Board, there will be conducted a sampling survey of the membership on the following items:

A. 12 issues vs. 6

B. Re-publication of convention papers in IQC

C. Reader interest in the News Supplement

D. An expression of reader habits

It will be of interest to many members that the Editorial Board has already started to screen and evaluate the papers presented at the Philadelphia Convention for the purpose of publishing selected ones in IQC. The bound Conference Paper volumes which were available at the convention are sold out and reprinting of the volume will not be undertaken.

The final action of the Executive Committee related to the problem of the reorganization plan. Under the new plan not every section is represented on the Board of Directors and every district may not necessarily be represented on the Executive Committee. There arises, therefore, a communication problem of insuring that each section and district be definitely informed of the actions of these groups. The Committee decided that the surest method of furnishing this information to everyone who needs it is to send the minutes of meetings of both the Board of Directors and the Executive Committee to the Board members, the District Representatives, and the Section Chairmen.

MEMBERSHIP CORNER

Now is the time to pick the fruits of last year's memberships. Don't fail to gather this crop, for it is ripe. Neglected, it will surely decay and fall.

And let's go after this crop systematically. First, the section secretary should compile a list of all the non-renewing members and turn it over to the membership committee chairman. If you are this chairman, this is where your work begins. The best starting point for you is to refer to the general methods which were

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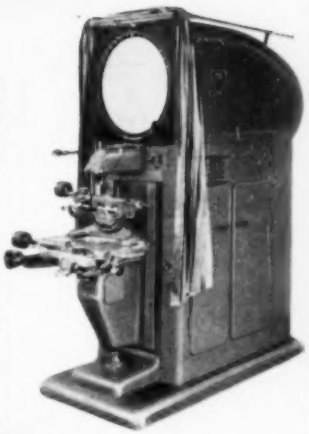

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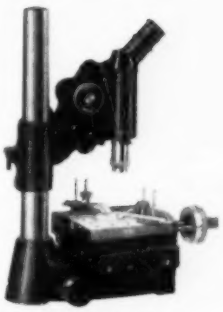

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set up by the national Membership Committee and which have been distributed to all sections. Here is the essence of a good sound procedure. If you will alter it slightly to fit your own needs and print it on your own section stationery, it will serve you well. Follow all of the steps suggested for no one of them alone will do the job.

As a last but all-important step, be sure to visit personally each non-renewing member. He may have just lost interest or he may have a very justifiable complaint which you should know about and can remedy.

But the system you use is not nearly so important as the fact that you do it. And do it now, for the crop is ripe.

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INDUSTRIAL QUALITY CONTROL	
Vols. I-IX (June 1944—May 1953)	$8.00 per volume including Index
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Third Annual Convention "Abstracts of Papers" (41 papers) Bound Volume	1.50
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Sixth Annual Convention "Quality Control Conference Papers 1952" (47 papers) Bound Volume	3.50
REGIONAL CONFERENCE PROCEEDINGS	
Middle Atlantic Region, 1950 "Second Annual Quality Control Conference Papers" (18 papers) Bound Volume	2.50
Middle Atlantic Region, 1951 "Proceedings, Annual Middle Atlantic Regional Conference" (16 papers) Bound Volume	2.50
Midwest Region, 1951 "Sixth Midwest QC Conference Papers" (19 papers) Bound Volume	2.50
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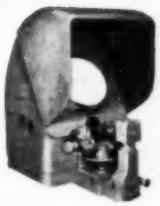

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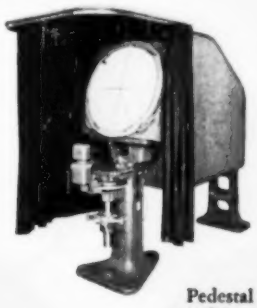

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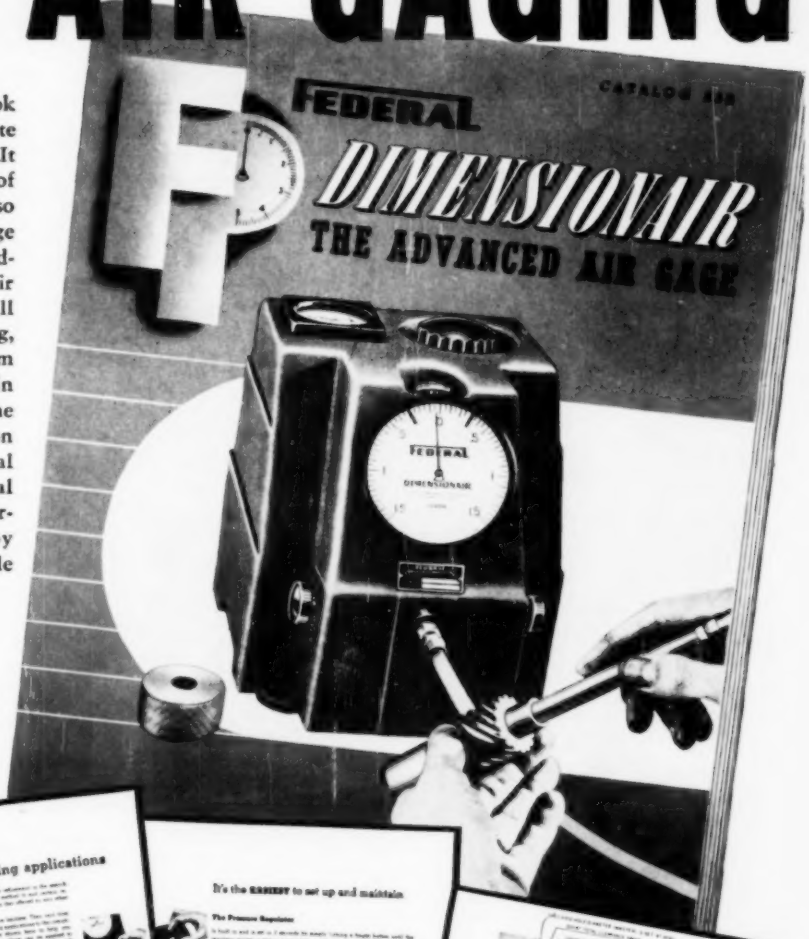

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